HANDBOOK
OF
MOTION PICTURE
PHOTOGRAPHY

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The HANDBOOK of MOTION PICTURE PHOTOGRAPHY

By

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To our many friends and students whose loyalty and cooperation have made possible this great work, we respectfully dedicate this Handbook.

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HERBERT C. MCKAY.

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Chapter One

THE FIELD OF CINEMATOGRAPHY

Familiarity with one or two common phases of any art or craft too often leads us to ignore other phases which may possibly be of even greater value. In no instance do we see this statement confirmed as it is in the field of motion photography. To the man in the street motion pictures still mean either the "Movies" at his favorite theatre or a miniature outfit for making the "Movies" at home. Notice that to him they are the "Movies." They are nothing but amusement. Whether in the home or in the theatre, the motion pictures seldom rise above the level of pure amusement, pastime! Even in the same manner, the word "Literature" to many people means the collection of frothy magazines of the Jolly Jingled Jimmy class. Too many of us refuse to realize that in the motion picture we have a tool and a weapon which will in time rival the supremacy of the printing press.

The printing press is handicapped by two things. It deals not with facts, with details, but with a vague description of such things conveyed by an artificial and an arbitrary system of language! Second, the appeal of the press is limited to those who can read the language which is printed. On the contrary, the motion picture presents, not description but concrete facts, incidents re-created. Also, the picture is the only universal language yet produced. An Englishman, a Frenchman, a Turk

and a Chinaman might be at a loss as to some common medium of conversation, but each would comprehend and appreciate a motion picture. Let us carry our comparison even farther. Suppose that each of the four understood a fifth language, German, for example. Now let a German describe to these four an incident which has occurred.

Due to the limitations of any language, a complete and fully detailed description of the slightest incident would take hours, so it is common practice to lump relative points of description and thus convey not details, but general impressions. Our German will do this. Each of his listeners will interpret the description in a different manner. The interpretation of each will depend upon (a) his familiarity with the German language (b) his racial and national ideas and (c) his individual ideas and past experiences. We can easily see that under the influence of these three things each man will carry away a mental conception which differs absolutely from any of the other three.

On the contrary, let us show this group of men a motion picture. As man interprets not only verbal description, but to a lesser degree fresh experience in the light of past experience, the men will have before them a new experience. This new experience will be very slightly tinctured with past experiences, but to such a slight degree that in each case the mental impressions derived will closely approximate the other three. No matter how great a linguist any man may be, no verbal interchange of ideas will impart the clear cut, definite information which the motion picture gives, and thus we can readily

understand that it is the only method of communication which may truthfully be said to be universal.

Language, under any circumstances is an artificial thing; the motion picture is a veritable re-creation of Nature.

In view of these facts, it is difficult to overestimate the value of the motion picture to modern civilization. Business, life in general in fact, is hampered because we have no means of definite communication. For this reason students are required to congregate in laboratories so that the instructor may **show** the things of which he lectures. For this reason skilled mechanics are required to spend a certain period in the factory where the mechanism with which he is to work, is manufactured. Modern life from the arts to mechanics depends upon demonstration. This fact is an acknowledgment that our language is deficient.

It is only fair to consider the shortcomings of the motion picture. Abstract ideas are vague things. They can only be communicated by the medium of words. So we find that the motion picture must be supplemented with subtitles. But the nature of the abstract is such that a mere hint is of as great value as detailed description, for again we meet the obstacle of personal idiosyncrasy. For this reason the subtitles dealing with this part of our communication may be kept to the minimum, and be of such nature that translation into any language is easy. Again, we need the subtitle for purposes of emphasis. But in this case they need be even less extended than in the first case. So we find that in the motion picture **without subtitles** we

have a medium of communication which is more flexible and in every way superior to the spoken or written word, but when we insert the simple subtitles, we have a medium which is as perfect as we can hope for until such time as we may succeed in direct thought transference.

Yet, with such a medium at hand, we have allowed it to sink to the level of a pastime. The theatrical motion picture forms the basis of one of the greatest industries the world has ever seen, yet this is the most ignoble purpose to which this marvelous medium can be put.

With the advent of the amateur motion picture apparatus and the consequent familiarity with the process, existing conditions are rapidly changing. There are literally hundreds of cases where the possession of one of the small outfits has led the owner to adopt standard films in his business and profession. Because of this, the value of the miniature outfit cannot be overestimated. Whatever may be its shortcomings, it has justified its existence through having opened the doors of modern civilization to the universal adoption of the motion picture.

There is no field of endeavor, no business, no art, no profession, no sport, no system of education which cannot be benefited to an infinite extent by the use of the motion picture. The great organizations have their motion photographers, just as they have their still photographers, but the smaller organizations cannot do this. In consequence we have opened to us an entirely new field, that of the commercial cinematographer. The commercial cinematographer will soon be of far greater importance than the commercial photographer, but more than this,

every photographic specialist will soon have his co-worker in the motion field. The portrait photographer, the commercial photographer, the scientific photographer, the expeditionary photographer, the photographer in whatever line must either master the principles of motion photography or make way for a more aggressive competitor. The purpose of this manual is to give in the most condensed and convenient form, the information necessary to gain such a mastery.

Such a manual must perforce cater to two distinct classes of individuals. First the newcomer who is totally ignorant of the principles of photography and second the still photographer who must "unlearn" to a certain extent before he can begin to learn the principles of motion photography. For this reason there will be included many things of an elementary nature, but only such of these as have a vital bearing upon the subject at hand.

Chapter Two

PRINCIPLES OF CINEMATOGRAPHY

In order to gain a fair idea of the scientific laws which form the basis of motion photography, the subject must be divided into these subheads: (a) the nature of light, (b) refraction or lens action, (c) photo-sensitive materials, and (d) the mechanism of the illusion of motion.

In so far as pure photography, that is the action of light, lenses and sensitive material is concerned, photography and cinematography are identical. It is only in the application of certain mechanical principles that they are diametrically opposed. For the present we shall concern ourselves with pure photography only.

The camera is a mechanical instrument, and the lenses, the sensitive material, all of the equipment in fact is of coldly mechanical and scientific nature, but the results secured often rival the finest masterpieces of the world. What is the artistic medium? Light! Light is the true medium of expression, the rest is merely a collection of tools. It is then evident that before mastery can be achieved, the photographic artist must fully understand the subject of light, lighting and lens action.

The Nature of Light

Vibration is life. Only at the extremely low temperature called absolute zero (273° below

zero, centigrade, or 460° below zero fahrenheit) is vibration supposed to cease. At all temperatures above that point, we have some degree of vibration in every object in the Universe.

Now these vibrations may be extremely slow or extremely rapid. Most of them have no effect upon any of our senses, but it so happens that certain groups of vibrations affect our ears and we hear sounds, other groups affect our eyes and we see light and color, other groups give us the sensation of warmth, others carry our radio signals and so forth. All vibrations have at least one common characteristic, their path of travel is undulatory, and this we call the "wave." Sound is transmitted by waves in the air, so cannot traverse a vacuum, but as light is carried by etheric waves, it passes anything whose molecular structure is such that the extremely rapid and extremely small wave motion is not interrupted. It is known that radio waves vary from one meter (experimental) to several hundred meters in length. Light waves, on the other hand, vary from .0007 millimeter to .0004 millimeter in length. Thus the longest light wave (visible) bears to the shortest radio wave the ratio of .0000007. We also know that both light and electrical impulse travel at the rate of 300,000 kilometers per second, or 300,000,000,000 millimeters per second. We also know that the rate of travel divided by the wave length will give us the frequency. Then 300,000,000,000 ÷ .0007 will give us a frequency of 428,571,428,571,428 vibrations per second. Now as a matter of fact the decimals .0004 and .0007 are round numbers. The scientific limits of the light waves in fre-

quencies lies between 392,000,000,000,000 and 757,000,000,000,000 per second. This is equivalent to absolute wave lengths of .00076 and .00039 millimeter.

However, below the red visible rays (.00076) we have the infra-red rays which are in fact heat rays. Above the visible violet (.00039) we have the ultra-violet or chemical rays. The infra-red rays need no consideration here. As for the ultraviolet, they are of some consequence to us. The usual photographic sensitive material responds to the stimuli of light rays which extend from about .0006 well up into the higher invisible rays. The response is least at the lower end of the scale, about the visible green and increases as we get into the ultraviolet.

In order to understand the limitations of our optical systems, we must recognize the fact that "transparency" is a relative term. Glass is transparent to visible rays of light. Iron and other sheet metals are transparent to heat rays and so forth. We find that ordinary glass is opaque for the higher ultraviolet rays while quartz is transparent to these same rays. We also find that certain kinds of glass admit shorter rays than do others. So, because the glass from which our lenses are made is opaque to some very short waves, the wave band which is used in a practical manner in photography is that which extends from about the middle green up into the ultraviolet a short distance. This fact must be remembered as it has a very important bearing upon this subject.

It may be added in passing that lenses of quartz have been made which give a relative

four times exposure at the same opening as a glass lens, but these quartz lenses have not been made subject to the correction possible with glass lenses, and so give a soft (unsharp) picture. Also, very recently a glass has been produced which is fully transparent to the full ultraviolet band. This may prove to be useful in lens making. However, as glass of two or even three different formulae must be combined to produce a lens of highly corrected quality, we shall probably have to remain content with the glass lens in the anastigmat class.

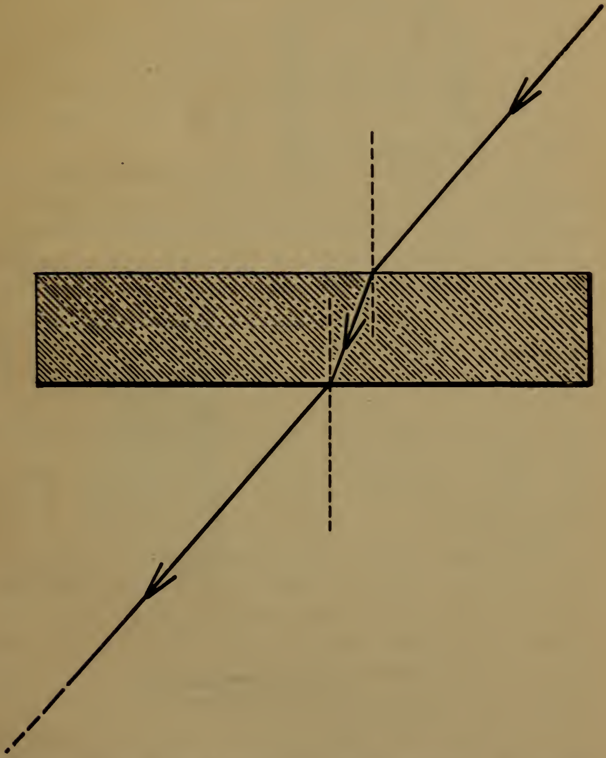
Sunlight, or white light, or daylight, is composed of the whole visible spectrum. This light contains every known color, shade and tint, but for convenience it is divided into seven arbitrary bands. First we have the three primary colors, red, yellow and blue. These color families occupy the lower end, the middle and higher end of the spectrum, respectively. Then we have the midway colors, orange, green and violet. And for good measure we have added indigo. Now we have the complete spectrum, red, orange, yellow, green, blue, indigo and violet. Note that violet is a type of purple and that purple partakes of both red and blue. While the visible red is the lowest color in the spectrum it is evident that the cycle is entering the red band of the next higher octave of color and that if we could see the ultraviolet rays, that in them we should find a second spectrum octave composed of colors analogous to those with which we are familiar.

In view of this fact we find that color, per se, has nothing to do with photography, but that the vibration rate which produces the sen-

sation of color in our minds, has everything to do with it. In other words, photography is based upon the effect of certain vibratory rates, of certain etheric wave motions which impinge upon the sensitive plate and leave a permanent impression. Color, on the other hand is absolutely non-existent outside our own brains which use the color system as a convenient code for translating the vibratory rate of the wave motion of that particular form of radiant energy to which we have given the name "Light."

A light ray, which may consist of any group of color rays, will travel through any given medium in a straight line. This straight path is of course subject to the magnetic influence of any foreign bodies which may lie adjacent to the path of travel, but such influence may be regarded as negligible in the consideration of photographic optics.

Now let us liken the ray of light to a band of canvas and rubber. The rubber will stretch while the canvas will not. If we try to pull the band through a very narrow opening, we find that the more flexible rubber comes through more rapidly and this tends to curve the double band. This rough analogy may aid us in understanding the very curious phenomenon of refraction. Light passes through different transparent substances at different speeds. That is, it passes more easily through some substances than through others, just as waves are set up more easily in water than in molasses. Now if the light ray strikes the surface of a transparent object at an angle, the entire ray is subject to displacement. Its path is bent at an angle. This angle is constant for various substances



When a ray of light strikes another medium of greater or lesser density than the one it is leaving, unless it strikes exactly perpendicular to the surface of the new medium, it will be bent or refracted. Illustration shows a ray passing through a block of glass and suffering two refractions, one upon entering and one upon leaving. In this case the two surfaces being parallel, the first refraction is neutralized by the second and the light ray continues in its original direction slightly displacced but parallel to its original course.

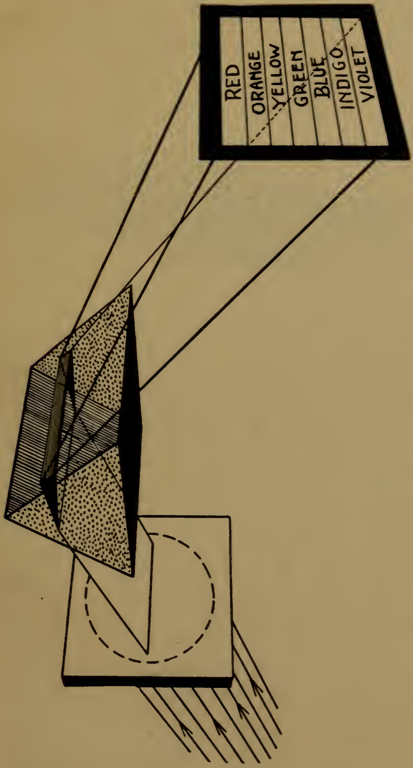
and its value is known as the index of refraction for that particular substance. As some kinds of glass bend the rays more sharply than others, we can in lens manufacture exercise control over the light path by combining glasses whose refractive indices differ, one from the other.

This bending is easily understood when we remember that any wave motion has height as well as width and length. The height is known as the amplitude. Now if this ray has a definite height, and falls at an angle upon any substance which slows up the rate of travel, the side of the wave which strikes the surface first will be slowed up while the other side travels at its initial velocity until it too strikes the surface. If we hold back one side of a wave and allow the other to travel, a sharp bend in the ray is the only possible result. This is just what takes place.

However, during this course of bending we see another strange effect. The high velocity violet waves are bent more sharply than the slower red ones, and so on. We find that not only is the entire ray bent, but that the various colors are separated. By bending the rays twice in the same direction, we can bring this separation to such a point that it is very easily seen by the eye. This is the principle used in the spectroscope.

Thus far we have found that light is a wave motion, that it is a complex band comprising the various wave-lengths between red and violet, that the path of the ray is bent by different transparent substances and that the different colors are bent to different degrees. This is

about all we need to know of the nature of light just now.

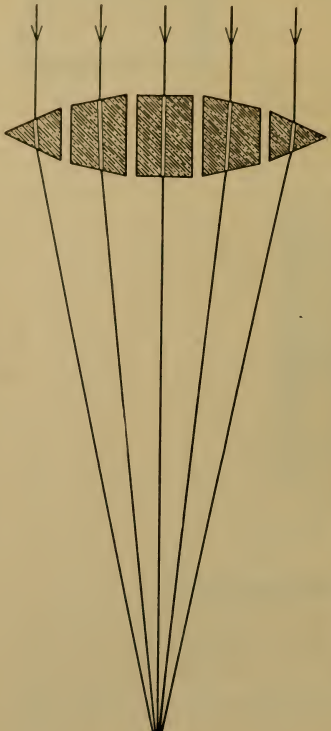


Production of the spectrum by means of a prism

Refraction and Lens Action

We secured the separation of the spectrum by bending the ray twice in the same direction. This is accomplished by means of a triangular prism. The optical prism is the basis of the most important tool of the photographer, the lens.

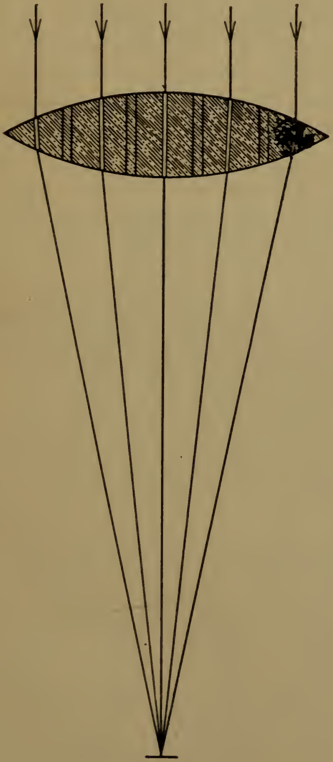
The prism refracts light in only one direction and that parallel to and passing through the axis of the prism. It is useful for analyzing white light, but not for image formation.



Illustrating the relationship between lenses and prisms. If we consider a lens as consisting of innumerable small prisms built up around a common center this relationship will become apparent.

Let us suppose that our prism is absolutely flexible. We pull the two ends together and compress the base until it loses all length. As a result we have a figure which may be likened

to two squat cones placed base to base. This we may call a circular, concentric prism. If we submit to its action a narrow ray of white light



This is the same as previous figure with the proper curved surfaces substituted for the angular surface of the joined group of prisms.

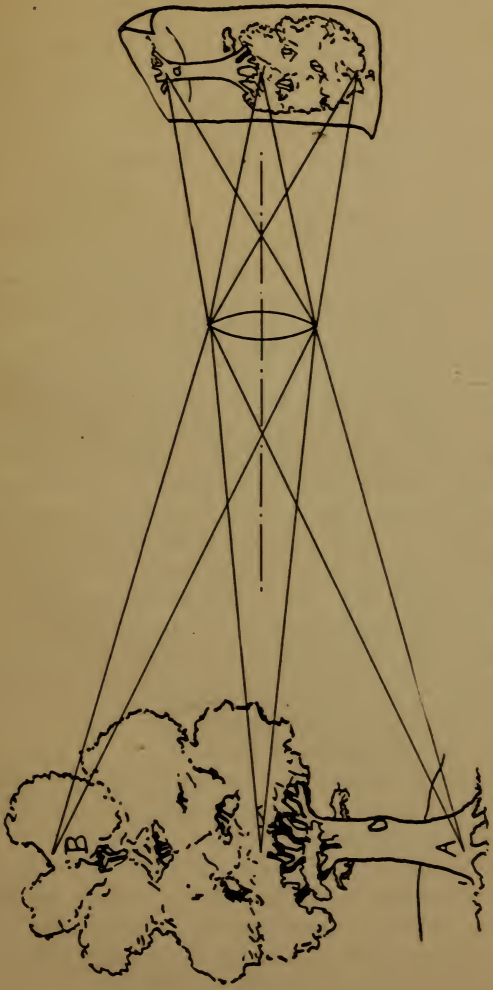
we shall see the phenomenon of analysis presented in a strange manner. The different colors instead of being displayed successively upon a plane, are projected in different planes, so that if we place a screen in such a position

that we have a spot of violet in the middle, the other colors will be found in concentric rings about the violet center and as the screen is moved away from the prism the different colors occupy the center in their spectral order. This is a point of great importance in photography.

Let us take this concentric prism and grind the surface until instead of two straight sided, conical surfaces, we have two spherical surfaces. We still have the concentric prism but in a modified form known as a **lens.** This is the simple spherical lens, and almost worthless for photographic use, but it illustrates the lens action.

As every object may be considered as having a surface made up of an infinite number of **points,** we shall consider, not surfaces as units, but a **single point,** knowing that any demonstrated fact is applicable to every other point concerned, and to that extent facts concerning points hold good for surfaces, but in a complex manner.

Objects are rendered visible by rays of light reflected from these points. Light reflected from a point travels in all directions. Therefore the rays of light reflected from a point in the surface of a wall travel in a path which is approximately hemispherical. Somewhere in this path we insert a lens. Now the reflected rays which cover this lens and which emerge from the point in question, form a long narrow cone, whose apex is the point in question and whose base is the lens. These rays are bent twice as in the usual prism and when they emerge from the opposite surface of the lens they converge sharply. They come together at



Production of an image by a lens

a point of "focus." Again we have a cone whose apex is the focal point and whose base is the lens. Thus the total path of this beam from the point is represented by two cones whose bases are common. The point of origin and focal point may be joined by a straight line which will be found to pass through the optical center of the lens.

Now let us repeat this process with two other points, one at the top of the wall and one at the bottom. As the axis of the beam must pass through the optical center of the lens and as this axis is a straight line it follows that the upper point will have its corresponding focal point below the first or central focal point and the lower point will have a high corresponding focal point. Repeated with two lateral points we find the same inversion. Now if this process is carried on with all existing points in the original we find that we have produced with the focal points, a reproduction or "image" of the wall which lies in a plane determined by the focal points and known as the "focal plane." We have also seen that this image is upside-down and reversed as to right and left. This may be known as the primary lens image. This is not a photographic image, which is a tangible thing of silver, but a lens image, which exists only during the time that the rays are controlled by the lens.

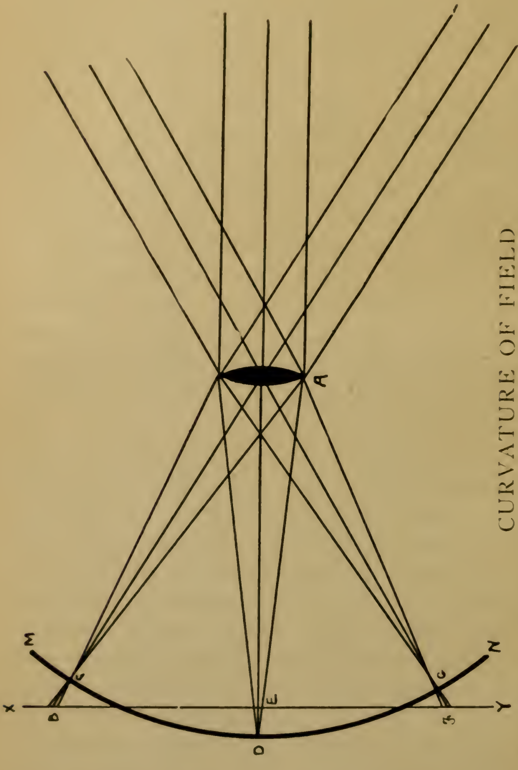
This primary lens image or optical image is far from perfect. As our lens is made of two spherical surfaces, we find that the entire ray is bent more sharply at the edges of the lens than at the center, due to a more acute angle of incidence. This means that rays passing

through the edges of the lens are brought to focus in a plane which lies nearer the lens than the plane of focus of central rays. As rays from every point pass through every portion of the lens, we find that, due to this fault or "aberration" of the lens, the focus of each point is not a true point, but a straight line perpendicular to the center of the lens. If we insert a ground glass or other screen in the focal plane to make the optical image visible, we shall find that the points are not sharp and distinct, but blurred and confused, nor can we find a position for the screen which will give a sharp image. The whole image in unsharp, and may be made sharp only by controlling the rays so that the focal lines shall become true focal **points.** This fault of the lens is known as **spherical aberration.** It is corrected by changing the surface curvature from the true spherical to a more flattened form.

With a spherically corrected lens, let us repeat the experiments. We now find that the farther the object is from the lens, the closer is the focal point to the lens. As the sides of an object are farther away than the center, we find that the focal plane tends to become spherical instead of flat. This gives us an image which upon a flat screen is sharp in the center and blurred at the edges, or vice-versa. So we next correct the lens for **curved field.**

Now with the flat field, spherically corrected lens we again experiment. We have seen that the lens separates colors as does the straight prism, and that the blue rays come to a focus much nearer the camera lens than do other rays, and that each color has its own focal

plane. This is known as **chromatic aberration.** It is corrected by using glass of two different refractive indices, one of them an ordinary positive converging lens, the other a negative

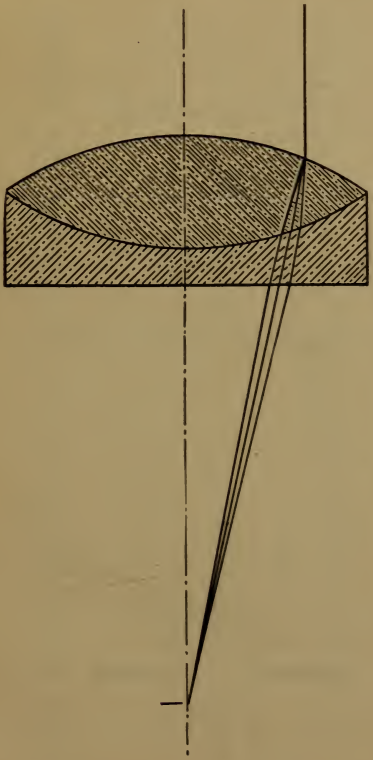


CURVATURE OF FIELD

A perfectly spherical lens would bring the three light rays to focus at points C, D & G. This would give large circles of confusion on the plane XY at points B, E & F. Flat field lenses are designed to shorten the central focus and to lengthen the focus of oblique rays.

lens, which is thinner in the center than at the edges, and which diverges or scatters rays instead of converging them to a point. This combination, by a double refraction brings all of

the colors to focus in the same plane, and is known as an **achromatic** lens. The simple achromatic lens is the simplest lens which may be used for any kind of record photography.

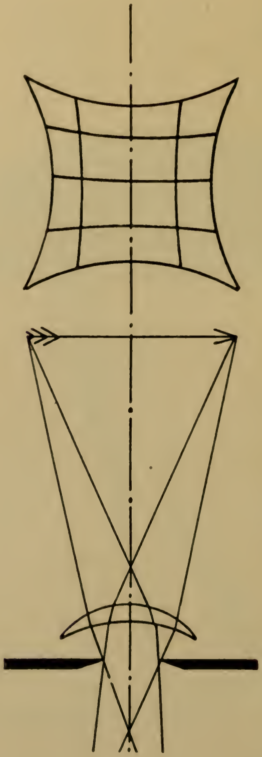


Correction of chromatic aberration by means of two lenses of different refractive indices

Uncorrected lenses are used at times to secure purposely unsharp images for pictorial purposes.

Using the simple achromatic lens we pursue our study. We find that with this lens we still have some degree of spherical aberration and

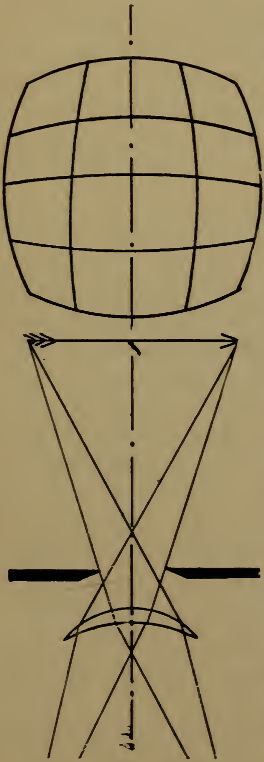
curved field. This residue of aberration is due to the peripheral rays, so we place before the lens an opaque screen in which is pierced a round hole whose diameter is considerably less



Pillow distortion. This is the effect secured by photographing a rectangular object with a simple lens which has the diaphragm behind the lens.

than the diameter of the lens. This is the **diaphragm.** In this case its purpose is to screen out the peripheral rays and enable us to work with the central rays only. This gives us a

good sharp image, but it introduces a new fault, that is distortion. When we produce the image of a square object upon the screen we find that the sides of the square curve inward. We call



Barrel distortion which is secured when photographing a rectangular object with a simple lens with the diaphragm in front of the lens.

this "Pillow" distortion. If we now place the diaphragm behind the lens, we get the sides of the square bulged out in what we term "Barrel" distortion. It would seem that this would

require two diaphragms, but the two diaphragm system is not practical, so we use two lenses, one before the diaphragm and one behind. This forms the **rapid rectilinear** lens, which is free from the linear distortions mentioned above.

The term "Rapid" was added to the name of the lens, because it was found that this combination of two achromatic lenses, produced a new lens whose focal length was one-half that of one single achromatic element, and whose equivalent speed was **four times** that of a single element.

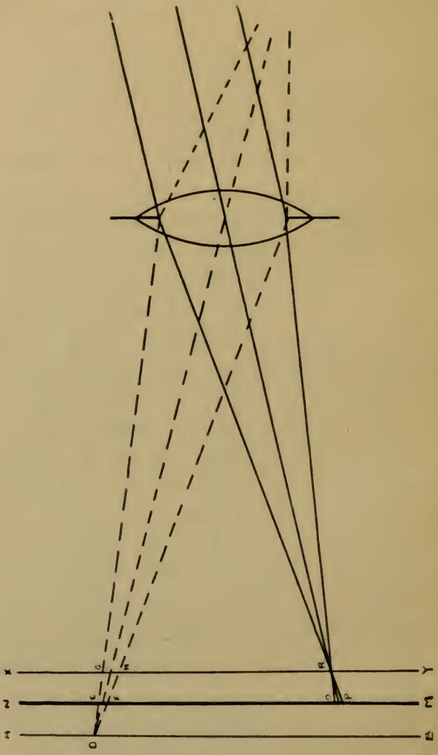
For some years the rapid rectilinear lens was regarded as practical perfection. In fact its faults were only recognized when enlargement became the universal practice and as motion picture projection represents photographic enlargement at its greatest, the rapid rectilinear lens proved entirely unsuited for motion photography. The outstanding fault of the rapid rectilinear lens was its astigmatism. That is in photographing a brick wall, the horizontal crevices would be sharp while the vertical ones would be unsharp or vice-versa. This lens could not bring to a simultaneous sharp focus both horizontal and vertical lines. Also it had vestiges of spherical and chromatic aberration. All of these aberrations were so slight that they were unnoticeable in contact prints, but became very apparent in enlargements.

Optical research now developed a new form of lens. Starting from the simple lens, a new form was calculated which would be free from all aberration. When this lens was first made it had a speed almost double that of the rapid rectilinear. From that time the development of

the modern anastigmat lens has grown until we now have lenses of the extreme aperture of f 1. So brilliant are these lenses that the image on the ground glass is more brilliant than the original scene, the lens acting as a condensor. Anastigmat lenses are characterized by being so free from all forms of aberration that enlargements to any degree may be obtained, the limit in size being only determined by the size of the actual silver grain itself.

This perfect lens is subject to certain optical laws, and to understand them we must first of all understand certain factors involved. First we have focal length. The focal length of a lens is the distance from the optical center of the lens to the focal plane in which focus of the sun's rays is obtained. This is the true focal plane. Let us say that this distance is two inches. Then we refer to that lens as a two inch lens. When objects nearby are focussed, we find that the focal plane is farther away from the lens and that when, in this case, an object four inches from the lens is focussed, the focal plane will lie four inches behind the lens, and the image of the object will be life size. Thus the closer the object the greater the back-focus (i. e. distance from rear surface of lens to screen) for any given focal length of lens.

Next we must understand the circle of confusion. We have seen that the rays converge to a focus. After this, the straight path continues and the rays diverge again, so that we have as the path of the ray behind the lens, two cones whose apices lie in a common point, which is also the focal point. Now if we place



CIRCLE OF CONFUSION

AB is the plane of focus for nearby objects, NM is the principal plane of focus or the focal plane as determined by the aperture plate, while XY is the plane of focus for infinity. The lens is focused for the hyperfocal distance. Rays from infinity focus in plane XY and the rays spread when crossing the principal focal plane, rendering a point as a circle whose diameter is OP. These rays are shown by solid lines. The rays from a nearby point, as shown by the dotted lines, come to a focus in plane AB, and when crossing principal focal plane they are still somewhat diverged giving a circle of confusion whose diameter is EF.

Some authorities give 1/250th of an inch as the permissible maximum in size for the cine circle of confusion, but by trying to hold to 1/1000th a better film will result.

our screen a short distance before or behind the focal plane we shall have the image of a point rendered not as a point but as a small circle, which represents a section of the cone of light. This circle is known as the circle of confusion or as the German people say with perhaps more reason the circle of diffusion. The circle of confusion is a definite expression of the degree of unsharpness of the optical image. We have seen that as objects approach the lens, the focal point draws away from the lens. Then if we have our screen in that plane in which lies the true focus for objects in the middle distance, we shall find that points in nearby objects and points in far distant objects will both be rendered as circles of confusion. Thus we may say:

Objects in only one plane may be brought to an absolute focus at one time.

It is evident, however, that if the eye cannot distinguish the difference between a point and a circle, that the circle will give an image which is apparently sharp. Thus we have found that for contact prints, any circle up to 1/100 of an inch in diameter will be seen by the eye as a point and that if the diffusion of the image is not in excess of this limit, we shall have a "sharp" image. For purposes of enlarging about 1/250 of an inch is the limit and the maximum for motion picture work is 1/500 of an inch.

In view of these facts we see that for all practical purposes **several objects in adjacent planes may be brought into satisfactory focus simultaneously.** Here we see the conflict of theory and practice.

The size of the circle of confusion is determined by the included angle of the cone of light rays. If the base of this cone is smaller, that is if the opening in the lens is smaller, this angle will be smaller and the focal planes may be separated to a greater degree without passing the limit in size, than would otherwise be possible. Now as we call this group of planes in which objects are satisfactorily focussed the "depth of field" and the property of the lens which enables it to bring these objects into such satisfactory focus the "depth of focus," it is evident that **depth of field and depth of focus are directly proportional and that both are inversely proportional to the size of the lens aperture.**

In other words, the smaller the lens opening the greater the depth. This holds good for a lens of given focal length only, for again,

The depth is inversely proportional to the focal length of the lens. The longer the focal length, the less the depth. This is due to the greater proportional differences in the focal lengths for nearby objects which is found in the lens of long focus.

So we find that our huge anastigmats have a very slight depth of focus. If we focus upon an object four feet away, the background will be only a series of smudges, amorphous and meaningless. This is not always to be desired, nor is it always good to use a wide open lens. In fact with motion cameras equipped with fixed shutters, it would be impossible to do so. For this reason we equip the lens with a changeable opening or diaphragm. This, in modern lenses, is a system of thin leaves which close

with a rotary motion and give a circular opening which decreases or increases in size at a uniform rate. This is the **iris diaphragm.**

When we have done this we have established chaos. We have an adjustment without a control. So we calibrate this diaphragm according to the "f" or focal system. This means that we divide the focal length of the lens by the effective diameter of the diaphragm and use the quotient as the f value. Thus if we have a diaphragm opening one quarter of an inch in diameter, in a two inch lens, we divide two by one-fourth and find the quotient to be 8. Thus this opening has a value of f8. A two inch lens of f1 has an effective diameter of two inches. The f values usually used are f1.5 — 1.9 — 2 — 2.5 — 2.7 — 2.9 -- 3 — 3.4 — 3.5 — 4 — 4.5 — 5.6 — 6.3 — 6.8 — 7.7 — 8 — 11.5 — 16 — 22 — 32 — 45 — 64 — 128. The usual motion picture lens is calibrated 2.7 — 3.5 — 5.6 — 8 — 11 — 16.

The diaphragm is used to increase the depth of focus and of field and to control the amount of light admitted to the film.

We find that at times we have a depth of field which extends from a point near the camera backward to include the farthest visible objects. When this is the case we find that we have three focal planes. First the plane in which objects in the nearest side of the band are sharply focussed, one in which objects far distant are sharply focussed and a third midway between these two. We find that upon this third plane, or hyperfocal plane, or plane of sharpest focus, we have sharply focussed the image of objects which lie at a distance from the camera which is just twice the distance of

the nearest object which is sharply rendered while keeping objects at infinity sharp. This is a very important subject. The distance of this third object from the lens is known as the **hyperfocal distance.**

When any photographic lens is focussed upon any object at the hyperfocal distance, every object which lies between a plane which is one-half the hyperfocal distance from the lens, and infinity will be sharply rendered.

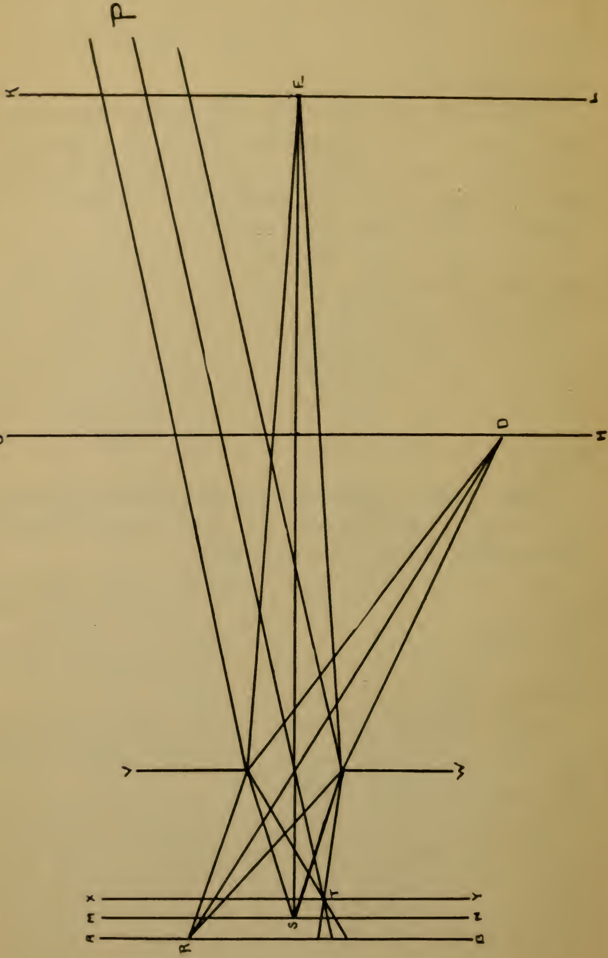
If the hyperfocal distance for a given lens is fifty feet, everything from twenty-five feet away to infinity will be sharp. But we have seen that objects in only one plane are sharply focussed and that any toleration is that of circles of confusion, so the practical use of the hyperfocal distance is dependent upon such circles of confusion.

Under given conditions the hyperfocal distance of a lens depends upon the size of the largest permissible circle of confusion.

But as the hyperfocal distance does depend upon the circle of confusion, it follows that the hyperfocal distance is controlled by the factors which control the circles of confusion and through them the depth of field.

Other conditions being equal the hyperfocal distance is greater with (a) long focus lenses (b) large aperture lenses.

So we find that the greatest accommodation is secured with short focus lenses of moderate aperture. So great is this accommodation that a motion picture camera with lens focussed at 25 feet and diaphragm set at f11 may be used as a fixed focus camera and produce film which is perfectly satisfactory.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HYPERFOCAL DISTANCE

AB is the plane of focus for near objects lying at half the hyperfocal distance.

MN is the plane of focus for objects at hyperfocal distance and is the principal focal plane.

XY is the plane of focus for infinity.

GH is the plane at half the hyperfocal distance.

KL is the plane in which the hyperfocal distance is located.

VW is the iris diaphragm of the lens.

P is a beam of light coming from infinity.

E is an object at the hyperfocal distance.

D is an object at half the hyperfocal distance.

The rays from object E come to a sharp focus in the principal focal plane, the rays from object D come to a focus in plane AB giving a permissible circle of confusion on plane MN and objects at infinity come to a focus in plane XY giving a permissible circle of confusion in plane MN. It is evident that any object lying between plane GH and infinity will be focused in a plane which lies between AB and XY. It then follows that these rays will give a circle of confusion smaller than those from point D or infinity and are consequently in permissible focus. The lens of the ordinary "Brownie" type of camera is focused for a hyperfocal distance computed for a circle of confusion of about 1/50th of an inch.

Whether or not the hyperfocal distance can be utilized to eliminate focussing depends upon existing conditions such as diaphragm in use, focal length of lens, the distance of the object, etc. A formula for calculating the hyperfocal distance will be found in the appendix.

We have now seen that for motion picture work, we require an anastigmat lens of appropriate focal length, equipped with a calibrated iris diaphragm and with a calibrated focussing jacket.

Photo-Sensitive Materials and the Photographic Image

We have found that light may be controlled in such a manner as to form an optical image. Now if we could devise some manner in which this optical image could be rendered permanent and tangible, we should have the true photographic image or "light-picture."

We know that light exerts some kind of effect upon all objects, colors fade in cloth and other fabrics, yellow stains are bleached and other changes take place under the influence of sunlight. These changes are undoubtedly changes in molecular structure of the coloring matter, effected by the vibratory stimulus of the light wave. This result is obtained in a period of time which may cover years or it may be to all intents and purposes instantaneous. In modern photographic work, demonstrable impressions have resulted from an exposure of 1/50,000 of one second, while exposures up to 1/3000 of a second are common-place in highspeed photography.

So, if we have a material which may be made

to conform mechanically to the focal plane, and which will be chemically responsive to the stimulus of light action and to a degree which will correspond to the **quantity** of light which falls upon it, we shall have a means at hand for making the optical image a photographic one. Note at this time that the effective factor is **quantity.** If our image were to result from a given **intensity** of light or from a **period of time** which the light acted, we should be greatly limited in the practice of photography, but as it is we work with **quantity.** That means that if the intensity is low we allow it to act for a longer time and if the light is intense, we shorten the exposure.

The sensitive material which answers these demands is the modern photographic emulsion. This is a mixture of photo sensitive silver salts and gelatin and is maintained in the desired mechanical form by being poured upon glass, celluloid, paper, copper or other supporting surface. It reacts molecularly to a very brief light stimulus and this allows a chemical reaction to take place when the exposed emulsion is subjected to a chemical treatment known as development.

Briefly we have certain chemical substances which combine readily with oxygen. These are known as reducers. They act toward the haloid group, i. e., chlorine, bromine, floruine and iodine, as toward oxygen. Therefore a chemical reducer will remove bromine from, say, silver bromide, provided the silver has a less strong affinity for the bromine than has the reducer. Our emulsion contains silver bromine, in a stable form, the two substances silver and

bromine firmly locked together. When light strikes this silver bromide it unlocks them leaving them only loosely attached together. In this case, when the developer, containing reducer, is poured over the emulsion, the bromine leaves the silver and rushes to the reducer, leaving behind **metallic silver** in tiny granules. Now we see that the greater the quantity of light which falls upon the emulsion, the greater will be the number of grains of silver bromide which are unlocked and consequently the greater will be the deposit of metallic silver in the emulsion. This means that the area of the emulsion upon which fell the greater quantity of light will be the darkest and most opaque. Thus this first photographic image is black where the original object was white and vice-versa. For this reason we call this first image the **negative.** If we use the negative for a mask, when exposing a second sensitive surface to the light, the black silver will prevent the light from reaching the second emulsion which lies beneath the negative mask, while the light passes freely through the clear spaces in the negative which represent shadows. So upon development of the second image, we find that the color values are the same as in the original object and this second image we call the positive. It may be made upon glass, celluloid, paper, cloth or any other surface.

The only limitation we have in the formation of the photographic image is that the sensitive surface must be protected from all light except that which comes through the lens. So we make use of a dark chamber or **camera,** in one side of which is the lens and in the other the sensi-

tive surface. This is the essential photographic camera; the dark chamber, the lens and the sensitive surface. All other parts are only refinements added in order to enable us to operate the apparatus with more facility under practical conditions.

Thus with our camera, we have secured this new image, a permanent, concrete reproduction of a scene. This reproduction we call the photographic image or only a **photograph.**

This photograph is a very good representation of a scene from life, but it has certain drawbacks. It is in monochrome, it has but two real dimensions, depth being simulated by perspectives, and it is immobile. Now a still photograph is a very serviceable representation of a stative object such as a building or a tree, but inasmuch as man's life is a history of action, our greatest interest lies in the field of action and a still photograph taken in the midst of action will probably be a grotesque thing. We must add action to the photograph to produce the motion picture.

The Mechanism of the Illusion of Motion.

A real moving picture, a photograph whose parts move in relation to each other is so wildly improbable that we may say definitely that the moving picture is non-existent and impossible. The motion picture is quite another thing. By means of a simple illusion it simulates motion to such a degree that it is as effective as a true moving picture could ever be. To understand the mechanism of this illusion we must revert to the vibratory theory of light.

Light is a wave motion. A vibratory impulse

impinging upon a receptive or "tuned" surface will set up corresponding vibrations in that surface or object. In the eye we have minute organs wihch may well be said to be broadly tuned to the wave band which comprises the visual rays of light. When the waves strike these organs, they respond instantly, just as the radio does. We see instantly. Now we also know that mechanical vibration continues for an appreciable period after the stimulus is removed. In like manner we may consider that the retinal organs continue to respond to the vibrations after the wave has ceased to impinge upon the retina. In short **we continue to see after the light has disappeared.** Physiologists call this the phenomenon of the persistence of vision. That it exists is subject to very simple proof. In a dark room, swing a burning stick rapidly. When the blaze is extinguished, we see, not a point of glowing fire which marks the ember, but an arc or even a complete circle of fire. We know that the end of the stick can be in but one position at a given instant, but we "see" it in an infinite number of positions which go to make up the arc. Persistence of vision is proven.

The duration of this persistence is a variable factor, but the main average is about one-tenth to one-twelfth of a second. The motion picture standard allows for a persistence as short as one-sixteenth of a second.

Now, turn back the corner of a book and allow the pages to slip rapidly through the fingers, while looking at the page numbers. These numbers will "dance" about in the corner of the page. Now if we could substitute for these

numbers the figure of a man, this figure would "shimmy" and we should have a very crude motion picture. Now if we should take these pictures and arrange them carefully so that each succeeding one was exactly superimposed upon the preceding, we should have perfect "registration" and no movement would be apparent when the pages were skimmed through the fingers. Now, if we should leave these figures as they are, but move the position of one arm very slightly in each picture until at last we have it extended above the head, and should then skim the pages, we should apparently see this image of a man slowly raise his arm!

The illusion of motion is secured by rapidly exhibiting a succession of pictures which differ but slightly, and by keeping the whole cycle of change compressed within a period of one-sixteenth of one second or less.

This is a very old principle, and even before the advent of photography, toys were made which utilized this principle. Later, in the days of glass plate photography a battery of cameras was used to photograph a horse race and then lantern slides were made from the negatives secured. These were arranged in an adapter and shown upon a screen. Here we have the first motion photograph. It was exhibited at the Chicago World's Fair and caused wide comment. Due to the limitations of the equipment, this picture showed only one leap of the horse, but by repeating indefinitely the illusion of a horse running was well given.

The motion picture did not become practical until after the introduction of the celluloid film. This made it possible to use any desired footage

of negative stock in the camera. Following its invention the present form of the motion camera was evolved. Today it consists of an intricate mechanism which exposes sixteen individual "frames" or pictures every second. And in the case of standard film, these sixteen frames take up one foot of film.

The film must travel from one container to another, but it must be held immovable while being exposed. Thus the film has two movements in three periods, viz., uniform forward, intermittent forward, uniform forward. As the intermittent lies between two forward movements, allowance must be made for the change, so we have a "loop" or a length of film which is not under tension between the two movements. The camera action is: shutter closes, film moves forward ¾ of an inch, and stops, shutter opens and film is exposed, shutter closes and film moves forward ¾ of an inch and stops, shutter opens, film is exposed and so on, the entire cycle repeating itself sixteen times per second. Thus we secure the photographic images which are necessary, using one foot of film per second.

In projecting the same cycle is repeated. The picture is projected upon the screen, the screen is darkened and the next picture moved into place, it is projected upon the screen which is again darkened, and so on. And thanks to our deficient sense of vision, we do not see this alternate darkening and projection, but only the smooth succession of entirely different pictures which have such a smooth and faultless appearance of true motion!

Chapter Three

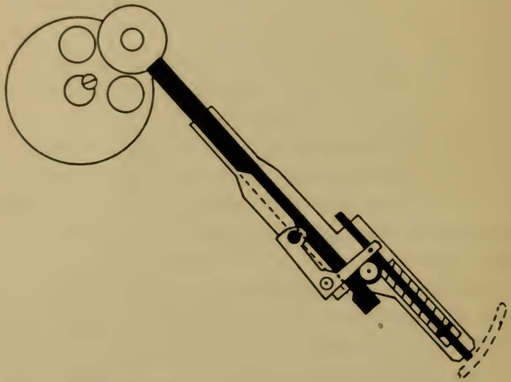
CAMERA, LENSES AND ACCESSORIES

There are certain elementary characteristics which all motion cameras share. These may be termed the essential qualities of the camera. The extent to which these essentials are refined depends upon the manufacturer.

In the first place, the body of the camera must be of such design that it is perfectly light tight. Should a light leak develop, the film will be blackened or "fogged" by this stray light and this would ruin the film. Our first concern then is to see if the camera body is absolutely light tight. The doors are the worst offenders. The edges of the door should have rebates or other devices to prevent any straight light path. Metal cameras are usually more durable than those of wood, especially when the camera is to be subjected to the rigors of news work or exploration. In addition to being light tight it must be of sturdy, rigid construction, capable of withstanding a great amount of abuse, yet it must not be too heavy. Either a tough aluminum alloy or pressed steel answer these requirements best.

Next we should consider the mechanism which advances the film. The choice of the mechanism depends entirely upon the work which is to be done. For ordinary, straight record work, almost any well constructed claw movement will give perfect satisfaction. However, if complex trick work is to be done which involves multiple ex-

posure of the same film and in which accurate registration must be maintained, the only movement which will give satisfaction is the harmonic cam movement with accurately ground claws and registration pins. This construction is only found in cameras costing thousands of dollars.



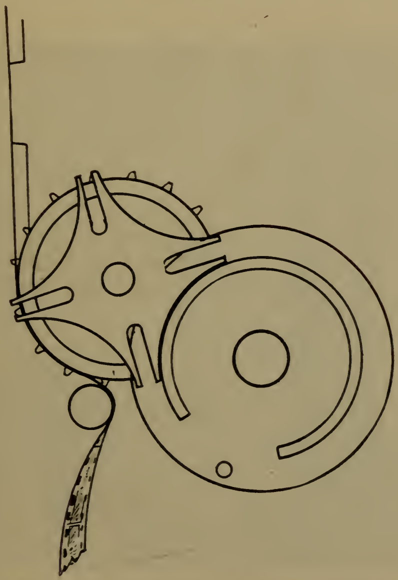
The single claw rod and crank movement of the Akeley Camera.

But as such work is only within the ability of the past master of motion photography, we will not consider it here.

The principal movements used are: the Geneva or star cam, the rod and crank and the harmonic cam. The Geneva movement is the partial turn sprocket which is the standard movement for projectors. This motion is found only in the cheaper models of cameras and is not entirely satisfactory as wear soon gives an uneven forward drive to the different film frames, which results in an uneven screen projection. This movement is entirely satisfactory in projection

because it is possible to maintain a proper adjustment in that case.

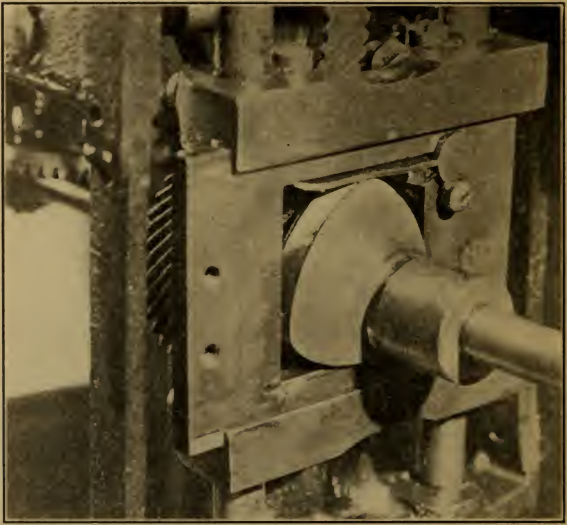
The rod and crank movement and the rocking claw movements are the most common. They consist of various crank movements with or without guiding cams. The spring actuated



The star and cam of the Geneva or Maltese cross movement

claw is inferior, but the movement which uses a cam or "D" guide is quite satisfactory. In such a movement the claw takes a circular path which is flattened on one side. The free claw travels upward in a circular path, but when it engages the film and starts downward it takes an approximately straight downward path.

The harmonic cam movement is a movement which is actuated by two cams. One of these imparts an up and down motion to the claws while the other gives a to and fro motion. Thus the claws, which are usually set into a carriage of some kind, move straight down, carrying the

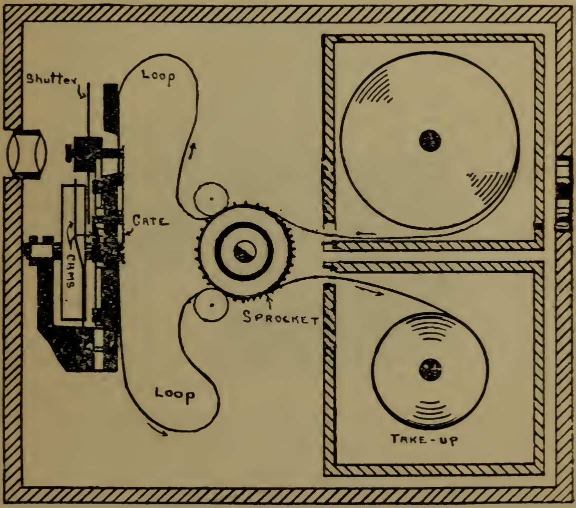


The harmonic cam as applied to a step printer

film, then straight back, disengaging the film, straight upward in a free motion, and straight forward to engage the film again, and the cycle is repeated indefinitely. The corners of the square path are barely rounded. With this movement there is no possibility of under traveling or over traveling, which gives us rock steady

projection, provided the camera as a whole was immovable during the exposure.

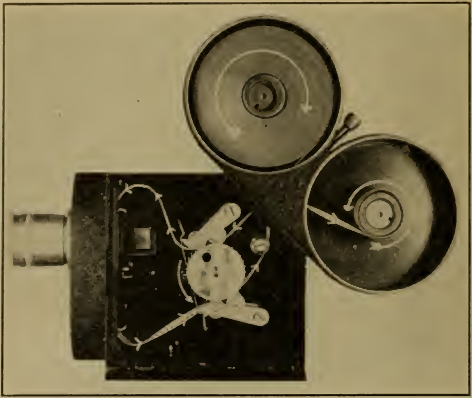
Theoretically the harmonic cam is the only practical intermittent movement for the motion camera, but in practice, the claw movements have been so perfected that they give entire satisfaction.



Diagrammatic section of a typical motion picture camera showing the path of the film travel

The claws themselves are of three varieties, the single bi-lateral in which a claw engages a single perforation on each side of the film simultaneously, the single uni-lateral in which a single claw engages one perforation on one side of the film only and the double uni-lateral in which the claw has two prongs and engages two per-

forations at once but both on one side of the film. Of these the true bi-lateral is beyond doubt the best, but we have the true bi-lateral only when the claws are accurately ground to fit the perforation. This we find only in the most expensive cameras.



The Institute Standard camera unit showing the path of film travel.

It is a strange fact, that the bi-lateral claw, which is not accurately made, may degenerate into the worst form of the three. Many cameras with bi-lateral claws depend upon this fact to maintain a uniform film motion, and the camera is not equipped with firm side rails. Then when one claw becomes a little more worn than the other, or when, through accident one claw is slightly sprung, the camera becomes a uni-lateral claw instrument without the design necessary to the satisfactory operation of such a movement.

In consequence the film travels in a zig-zag path which gives a screen dance whose magnitude is proportional to the amount of lateral movement of the film in the camera.

In cameras using the uni-lateral claw, side rails are provided to prevent any lateral movement of the film. In such cases it is evident that the downward movement must be steady and uniform. For all practical uses, the uni-lateral claw is to be preferred, for with such a movement any kind of film may be employed with certainty of good results. This is particularly true of travelers who often must use various makes of foreign film. The splendid results obtainable with the uni-lateral claw are shown by the work of the Akeley camera, which is unsurpassed.

As for the single and double claw in the uni-lateral movement, the extra claw only provides a margin of safety in case a weak spot in the film should allow the perforation to tear. The uni-lateral claw may be actuated by any form of rod or crank or harmonic cam. The DeVry camera has a double, uni-lateral claw operating in a "D" guide, while the Institute Standard camera has the uni-lateral claw operated by harmonic cam. Both of these cameras give entire satisfaction.

The intermittent movement is useless unless there is some mechanism which will pull the film from the upper spool, feed it to the intermittent and then dispose of the exposed film. The movement of the film from the first spool and to the second is a uniform, steady movement. As this must be changed to and from the step-by-step intermittent, a certain length of "slack" must be provided. So we have a sprocket pulling the

film from the upper spool, then some slack or a "loop" as it is technically known, the intermittent, the second loop, the second sprocket and then the take-up reel.

The first cameras had two sprockets, one to take film from the feed reel and one to take the film from the intermittent. It is obvious that should anything occur to disturb the synchronism of the two sprockets that either one of two things would happen. The lower loop would be lost and the film would be stripped through the gate, ruining the film and probably damaging the intermittent mechanism. If this did not occur the lower loop would be enlarged until the camera chamber would be clogged with film. In fact, these things did occur so constantly that the two sprocket system was changed to the master sprocket system. In this system the film is pulled from the upper spool by the top of one large sprocket, while the film is taken from the lower loop and fed into the take-up spool by the bottom of the same sprocket. In this manner synchronism is made positive. All cameras which make any pretentions to quality now use the master sprocket.

When the film leaves the lower side of the master sprocket, some means must be provided to take up this film. An ordinary drive will not suffice. When the film first starts the diameter of the spool axle is roughly one inch. Thus about three inches of film are taken up with each spool revolution. When the one-hundred foot spool is almost full the diameter is almost four inches, taking up about one foot per revolution. As the film must be kept under moderate tension between the lower sprocket and take-up spool,

some variable drive is necessary. This variable drive may be a belt driven arrangement in which the belt slips when placed under a predetermined tension, or it may be some form of a clutch which will slip when the tension reaches a certain point. The belt drive is best when the camera is equipped with outside magazines allowing the belt to be kept under observation, but with self contained cameras, the positive or clutch type is better.

So much for the film handling mechanism. The next point of interest is the exposing device. Such devices are called shutters, and there are numerous types available. However, every motion camera, except one, which has proven successful, uses the rotary disc shutter. The exception is the Akeley camera, which uses a rotary cylindrical shutter.

The shutter is a disc of metal, from which a certain segment has been removed. As the speed of rotation of the shutter is predetermined, it is evident that the length of exposure depends upon the size of this opened segment. As we shall see later, the motion camera does not need the extreme speed necessary in making still photographs of a moving object, and we find many very good motion cameras which have shutters of fixed opening. This opening varies from ninety to two hundred degrees. Using normal speed of one-sixteenth of a second as a basis for computation we find that such openings will give us exposures which vary from one sixty-fourth of a second to a trifle more than one thirty-second of a second. Experience has shown that for all around work the one hundred and thirty five degree opening is probably the best, and this gives

an exposure of approximately one forty-third of a second. While some loss of illumination is involved, the better stopping power more than compensates, especially as we may regain the illumination by the use of the extreme-aperture lenses now available.

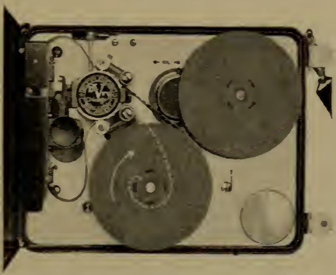
So far only simple shutters have been considered. There are two more types. The adjustable shutter and the dissolving shutter. These shutters are made of two similar discs, one of which revolves about the shutter shaft and thus makes possible a change in the size of the open segment. In the case of the adjustable shutter this change is made manually, but in the dissolving shutter the change is made automatically and may be operated while the camera is in operation, giving a steadily increasing or decreasing exposure which gives the effect known as a "fade."

Dissolving shutters are operated by turning a knob on the outside of the camera, or by pressing a lever which throws into action a train of gears giving us the manual and the automatic dissolves.

Next we have the film carriages. Film is usually carried in light tight boxes known as magazines, in the older professional cameras. These magazines may be either interior or exterior. In any case some kind of light tight opening is provided through which the film passes. In using magazine cameras a certain footage of film is lost in threading, but no spools, leaders and so forth must be paid for when buying and using plain perforated film.

The newer, self contained cameras use the daylight loading film which is based upon the same

principles as the usual Kodak film. The film is wound upon spools which have solid steel sides. There is no paper backing, but a length of dark colored film is attached to each end of the raw stock. This protects the film from light both when loading the camera and when unloading. The first length is roughly ten feet long, and the trailer may be six feet long. In operating such cameras about four or five feet may be used in



Interior of the DeVry automatic camera showing the daylight loading spool of film as used in these cameras

threading, then the film meter is set at 95 feet and five feet of film run through the camera. This leaves the meter at zero and should bring the fresh film behind the lens. This method is gaining in favor as it does away with the bulk and weight of magazines. The film spools are very slightly larger and heavier than an equal sized roll of raw film.

The final consideration is that of the mode of operation. Modern cameras are of two types, the motor driven and the hand-cranked types. Each type has advantages of its own, and the commercial cinematographer should possess one of each type.

The hand cranked camera is used when the subject is under control, when the movements of the subject may be anticipated and when it is possible to use a tripod. The hand cranked camera will not give satisfaction unless it is used in conjunction with a good, heavy motion picture tripod. The hand cranked camera gives the operator complete control of tempo. He can alter the screen speed of the subject by slightly altering the speed of the camera. In making titles, and in certain kinds of trick work the hand cranked camera is the only one practical. In animation, time condensation, scientific research and almost all special lines of work, the hand cranked camera is indispensable.

The automatic drive camera is a great advantage in shooting rapidly moving objects, covering emergency news events, in travel, in making pictures from almost inaccessible points and in ninety per cent of the average commercial work. In using the automatic driven camera, it is necessary to learn to hold the camera steadily. In this, the hip position is of great value if the camera is designed to be so used. This will be fully explained later.

So much for the camera itself. The camera is of no value without its accessories, or some of them. Accessories for the motion camera run the gamut from lenses which are essential to the lens turret which is purely a luxury.

The lens used with the motion camera may be any photographic lens, but in practical work, the choice is limited to a great extent.

The motion picture lens must be an anastigmat. The anastigmat is the only lens which will give the critical definition all over the frame

which will stand the two hundred and eighty-eight times linear enlargement which is not uncommon. When we stop to consider that five times is regarded as the extreme limit for the best of still negatives, we can begin to understand the wonderful quality which the motion picture image must possess. When the motion picture is projected upon a screen measuring eighteen by twenty-four feet, we have an enlargement of eighty-two thousand, nine hundred and forty-four areas!

The motion picture camera is rarely fitted with a shutter which gives a greater exposure than one thirty-fifth of a second, which is inadequate for full exposure under many usual conditions, and using an ordinary double lens. So we have to have our anastigmat of great aperture to allow full exposure under all ordinary conditions. The lens which was recently regarded as standard was the lens with an extreme aperture of f 3.5. However, the modern lens is one which works at a maximum aperture of f 2.9 or 2.5. In round numbers the f 3.5 is five times as fast as the f 8 rapid rectilinear, while the f 2.5 is twice as fast as the f 3.5. In other words, the motion camera will secure fully exposed film under conditions which would necessitate an exposure of about one-fourth second with the usual double lens equipped still camera.

The standard motion camera lens has a focal length of two inches, which is equivalent, roughly, to using a fourteen inch lens on a five by seven camera. Thus we see that the motion camera uses a long-focus, narrow angle lens. This gives better images at a distance from the subject. However, lenses are available whose

focal lengths vary from one to twenty inches. The lenses in common use have focal lengths of 35 millimeters, 2 inch, 3 inch, 4 inch, and 6 inch. For general news and commercial work, when only a single lens can be had, the three inch is recommended.

Various lens formulae and reference tables will be found in the appendix.

Hand cranked cameras require a tripod and automatic cameras have their usefulness increased by the use of such an accessory. For the hand cranked camera the tripod should be of very sturdy construction to prevent any motion in any direction. The tripod usually weighs from twenty to forty pounds. It is quite necessary that it be provided with a tilt and panoramic head. These movements are operated by cranks. The tilt head allows the camera to be pointed at any desired vertical angle, while the panoramic motion allows the camera to be swung through a horizontal arc. This combination makes it possible to point the camera at any object, regardless of its position. These motions may be used while the camera is in operation. A tall building may be shown from base to tower by operating the tilt while the camera is in operation and likewise a long panorama may be shown by swinging the camera laterally. These motions are necessarily slow as they are driven by gears, but in such work a slow rate of motion is quite essential. In the case of races and similar subjects where the subject is to be kept upon the screen regardless of the background, these movements are inadequate. For such subjects the automatic camera is used, which can be swung as rapidly as the body can be turned.

The tripod for the automatic camera may be quite light, such as is used for eight-by-ten view cameras, or a light weight motion picture tripod may be used.

The smaller attached accessories include finders, range finders, footage meters, frame counters, focussing loupes and microscopes, speed indicators, film punches, both iris and shutter dissolves operated manually and automatically, masking devices of various kinds and so forth.

The view finder as such serves to locate the field of view so that the cameraman can know what he is doing. There is some slight confusion regarding the use of view finders and focussing apertures. The view finder is an accessory which indicates with more or less accuracy the subject which is being photographed. This is its sole purpose. The focussing aperture is used, not to determine the field of view for photographic purposes, but to (a) provide a means of focussing the lens by visual methods and (b) to secure exact registration of double or multiple exposures, masks and so forth. The view finder may be of any type. For approximation of the view the Newtonian finder, the brilliant reflecting finder or the iconographic finder serve admirably. To insure success these finders include a smaller area than the actual frame.

For more exacting work, such as studio work, the finder which is a duplicate camera, is used. This consists of a tube in which is mounted a lens of the same focal length as the taking lens. This lens is usually in a focussing mount. In the rear of this lens is a ground glass screen. This device is fixed in the same horizontal plane as the camera taking lens. It is pivoted so that

the axes of the two lens systems converge. Thus the two lenses may be set to cover the same identical area in any plane before the camera. For infinity the two systems are practically parallel. For closeups the two systems converge sharply.

In using such a device, the finder lens is opened widely. This gives little depth of focus. The lens is then focussed, a loupe being used to determine critical focus. The focussing scale is read, the camera lens set to correspond and the range dial also set to the distance indicated. The finder lens is stopped down until the brilliancy of the image indicates the correct point. The camera lens is stopped down to correspond. Thus in the range-finder we have a complete visible check upon the camera system.

A footage meter of some kind is necessary. This may be a simple dial graduated in divisions each of which represents five feet, or it may be a complicated system of dials or a Veeder counter which indicates not only the number of crank turns or half-feet, but even goes so far as to indicate the number of individual frames exposed. The simple form is adequate for all record work as it merely indicates the relative length of exposed and unexposed film. The complicated meters are used upon studio cameras where film has to be reversed to one definite frame for trick effects.

When direct-upon-film focussing is provided a magnifying device of some kind is necessary. This may be a simple loupe or it may be a compound microscope. In all usual record work outdoors, due to the short focal length of the lens and the small stop used, such minute checks

are not necessary. By using the hyperfocal distance (see Appendix) focussing may be reduced to the minimum.

When film lengths in excess of two hundred feet are used, a mark must be made to indicate the parting point as most laboratory developing racks accommodate about two hundred feet of film. The film punch does this by punching a notch or hole in the film. The edge notch is more easily distinguished in the dim light of the laboratory. The film punch is not necessary on small capacity cameras if the scenes are slated. (q.v.)

We have mentioned the shutter dissolve. The iris dissolve is a method of securing the same result by closing the iris diaphragm of the lens. A similar but not identical result is secured by the use of the outside iris. These effects are not necessary to record and commercial work, and are not recommended for straight records. Their effect is more of a pictorial and dramatic nature.

Masks are used to either outline the picture as circle, binocular, key-hole, star and other openings or to divide the film area for double or multiple exposures. The fancy masks are used in a mask slot directly in front of the film, while trick masks are used either in this mask slot or in a mask box carried a few inches in front of the lens.

Minor accessories include color screens for orthochromatic and panchromatic effects and so forth.

Chapter Four

TRIPOD CAMERAS

The studio camera is a camera for the specialist only, and as such shall be only briefly considered. The studio camera is usually large and heavy and equipped with accessories and adjustments which are only confusing for the record worker. The studio camera requires a tripod or other form of rigid mechanical support, and is provided with automatic drive only in the form of the electric motor which renders it impractical for general commercial work.

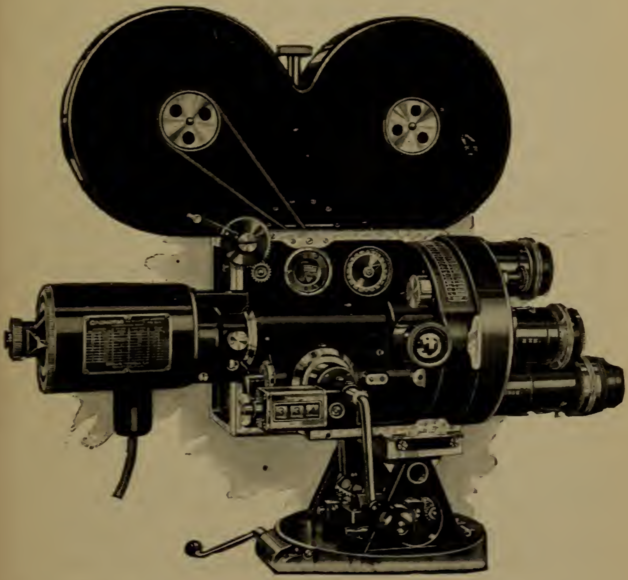
Moreover, the professional cameras are exquisitely made of the very finest material, hence their cost is often prohibitive.

The true nature of the studio camera will be revealed in the following brief descriptions of some typical cameras.

The BELL & HOWELL studio camera is the standard of the world. It is the camera which is used by practically every producing studio in the world. It is a beautiful instrument, made in shape to conform to the driving mechanism, with outside magazines which hold either 400 or 1,000 feet of film. The latter magazines are seldom used except in the case of super-speed work in which great lengths of film are exposed in a very short time. This speed reaches as much as sixteen feet per second, as against one per second which is normal.

The camera is of all metal construction, finished in a beautiful crystal enamel. It has no

tripod screw but is attached to the special tripod by means of a dovetail fitting which engages a corresponding channel in the tripod head. This allows the camera to slide from side to side to take advantage of the unusual focussing adjust-



The Bell & Howell Professional Studio camera, as used in the largest studios. This is the finest and most complete motion picture camera produced

ment. The front of the camera has a turret plate which carries four lenses, any one of which may be brought into use by a slight turn of the wrist.

The direct focussing device does not make use of the actual aperture, but of a corresponding one on the opposite side of the turret. Thus the

camera is set at the left side of the tripod and the lens focussed upon the screen provided. When this is done the lens is locked. Then the camera is pushed to the right of the tripod, the lens turret swung through 180 degrees, which brings the lens from focussing position to taking position, yet due to moving the camera, the lens is still in its former position. This allows focussing without disturbing the film, and allows a solid pressure plate to be used.

The intermittent movement is wonderful. The film is engaged by inserting it between two plates of the shuttle. This shuttle has a motion independent of the claw movement. When the crank is turned, the shuttle moves forward, carrying the film with it. The film is forced against two fixed pins which engage the perforations, and the film is forcibly pressed against the aperture plate. The exposure is made, the shuttle moves back, pulling the film free of the two fixed pins, the intermittent claws engage the film, pull it down into the next position, the shuttle moves forward and the cycle is repeated. The film moves with absolute freedom but when being exposed it is not only firmly clamped in place, but proper registration is assured by the two fixed pins. This accounts for the phenomenal steadiness of B & H film.

The magazines are of the outside, double type with a spring belt, visible takeup. The fade is operated by pressure upon a small lever. At the end of a fade-out the camera locks automatically and is unlocked by pressure upon a button. A hand fade is also provided. A scale indicates the angular opening of the shutter at all times.

Two film meters are provided, one a reset dial with pointer, the other a Veeder counter with a frame registering device. This allows the most intricate trick work to be done.

The tripod supports any mask box, shadow box or extreme long focus lens, taking the strain of such weight from the camera itself. Facilities are provided for attaching an electric motor.

The usual movements, eight to one, one to one and reverse are standard.

The Bell & Howell Specifications are:

CONSTRUCTION—Metal in black crystal enamel.

SIZE—Camera only 7 x 7½ x 7¾.

SIZE—With lens and magazine in place 7 x 14¾ x 15.

WEIGHT—With lens and magazine, 27 pounds.

CAPACITY—400 or 1000 feet standard film.

FINDER—Range finding.

LENS EQUIPMENT—4 carried at once. Choice optional.

FOCUS—Scale or direct sight. Aerial by microscope optional.

SHUTTER—Rotary, adjustable, automatic dissolve. Made of heavy metal, 6″ in diameter.

INTERMITTENT—Special B & H harmonic cam. Claws ground to fit standard B & H perforations.

MAGAZINES—Outside, double, metal.

TAKE-UP—Spring belt, visible.

MOVEMENTS—Normal, single and reverse.

METER—Dial on side of camera. Veeder counter at rear.

MASKING—Interior slot and mask box.

THE MITCHELL CAMERA

The Mitchell professional studio camera is a very complete instrument. It differs from other models in that it has several features built into the mechanism itself, including the split stage and fancy mattes, the adjustable four way mattes, a rising front adjustment and an iris which may be so decentered as to be placed in any part of the film aperture. The most important feature is the unique focussing device.

It is well known that the ideal method of focussing a motion picture camera is through the taking lens and upon a transparent or finely ground screen, depending upon circumstances. This should be done without the film being in place behind the lens, however the film should then be placed in position behind the lens without further disturbing the lens. This is done practically in the Mitchell, by having the camera body mounted upon a sliding base. The base is firmly fixed to the tripod, from the front of the base rises a vertical member which contains the various built in features. In this "L" the camera body proper slides from side to side. With the camera at the right of the base (from operating position) the finder body is placed immediately behind the taking lens. Now the lens is focussed. Then by grasping a "T" handle and pressing a button the camera body is moved to the left, the finder taking its place behind the finder lens and the film gate coming into position behind the taking lens in the same position previously occupied by the finder unit.

The Mitchell Camera

CONSTRUCTION—All metal.

CAPACITY—400 feet standard film.

MAGAZINES—Double, outside, metal.

TAKE-UP—Visible, spring belt.

LENSES—Turret for four or less at one time, any standard cine lenses.

MATTES—Built in.

4 WAY MATTES—Built in.

RISING FRONT—Built in.

IRIS VIGNETTE—Built in.

INTERMITTENT—3 cam type with positive tension and free moving film.

DISSOLVE—3 speed automatic and hand.

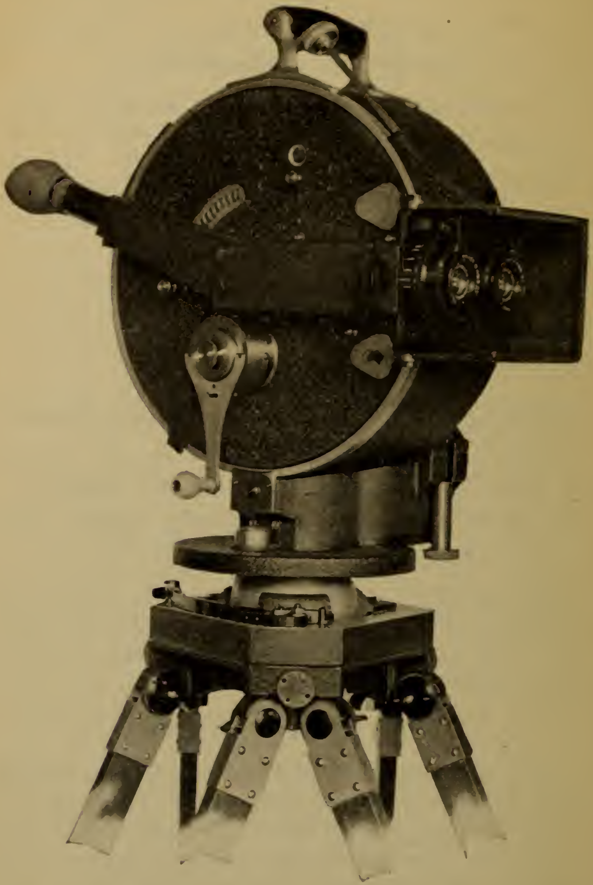
FINDER—Optional, range finding regular, telescopic and magnifying.

This camera has been adopted by some of the studios as regular equipment and is well liked by some cameramen, due to its many really unique features.

THE AKELEY CAMERA

One of the appeals of the motion picture field is its eternal, undeniable romance. Romance of a red blooded, husky kind has crept into every nook and crevice of the motion picture field. Perhaps this has never been exemplified to such an extent as in the case of Mr. Carl E. Akeley, Naturalist, Sculptor, Lecturer—and Inventor!

Mr. Akeley, in the course of his work for the American Museum of Natural History of New



The Akeley motion picture camera as used by explorers, big game hunters and others who need a camera which may be moved quickly and which may be used with extremely long focus lenses.

York, went into the African jungles, equipped with motion picture cameras of the usual type, for the purpose of filming the wild life of the jungle. Unfortunately, or rather fortunately as

The Akeley camera removed from its tripod and used upon a large rock. This camera may be placed upon any convenient base.

it turned out, Mr. Akeley did not succeed in securing the film which he desired, due to the limitations of the photographic equipment. Upon his return to this country, Mr. Akeley started working upon a camera of his own design, and

when completed, this camera lacked every one of the disadvantages which had prevented Mr. Akeley from securing the film he wanted on his first photographic trip. The camera was truly unique, and looked like anything but a camera.

Briefly, the camera may be leveled regardless of the plane of the top of the tripod, and may be panoramed in a strictly horizontal plane regardless of the position of the tripod. It has a floating finder, the eyepiece of which remains in the most comfortable operating position regardless of the camera position, which may be varied through a vertical arc of 140 degrees without changing the tripod, and by a slight tripod shift, may be operated in any position from straight down to the zenith. It has no tripod cranks, but a single lever control which permits following any object regardless of the direction of travel or speed of that object. Without alteration the camera will take lenses up to 18 inches focal length. The camera may be equipped with a shutter of 230 degrees opening, and it may also be operated at four times normal speed thus securing slow motion pictures without any accessory parts.

These are a few of the features which make this camera the ideal equipment for the naturalist and traveler. In addition the usual accessories such as shutter dissolve, Goerz iris and effects and so forth, may be readily secured, the shutter, of course, having to be installed at the factory.

The Akeley Camera

CONSTRUCTION—All metal, throughout.

SIZE—Camera CASE 9 x 14½ x 15½ inches outside.

SIZE—Magazine CASE 8½ x 8½ x 9 inches outside.

WEIGHT—Camera 22 pounds, case 11 pounds, total 33 pounds.

WEIGHT—4 magazines 7½ pounds, case 4 pounds, total 11½ pounds.

WEIGHT—Tripod 19¼, case 3½, total 22¾ pounds.

WEIGHT—Total weight of complete field outfit 67¼ pounds.

CAPACITY—200 feet standard gauge film.

FINDER—Akeley, full floating, "right-side-up" image.

LENS—Any cine lens of any focal length, with matched finder lens.

FOCUS—Direct with either taking lens or matched finder lens, at will.

SHUTTER—230 degree focal plane or 180 degree dissolving focal plane.

INTERMITTENT—Akeley special uni-lateral claw rod and crank.

MAGAZINES—Double, inside, with self contained master sprocket.

TAKE-UP—Inside, positive, with manual check.

MOVEMENTS—Normal and single crank.

METER—In side of door.

The Akeley camera has proven successful under every test to which it has been submitted and is numbered among the truly fine cameras of the world. Its many unique advantages have made it a favorite with travelers, explorers,

naturalists and others, and it has also been accepted for specialized work in the largest studios, the highest recommendation which can be given any camera.

THE DEBRIE TYPE

Probably the DeBrie type of camera stands next to the Bell & Howell type in the estimation of studio men. While neither the De Brie, nor any other except the Bell & Howell type is recognized as a true studio camera, this type stands far above the usual topical or news type of camera.

This type of camera is represented by three different cameras, the DeBrie, made by Andre DeBrie of Paris, the Ernemann, made by Ernemann of Dresden and the Askania, made in Berlin. The three resemble each other so closely that only the expert can tell one from the others. A type description will suffice for all.

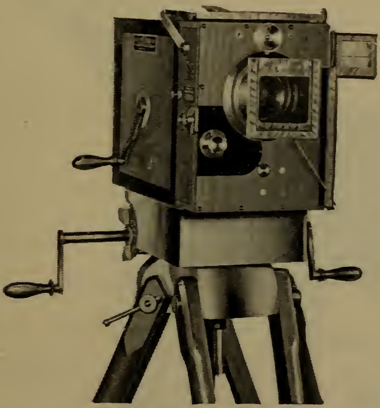
This camera is of regular, rectangular shape, and one of the most compact cameras of its capacity made. It takes 400 feet of standard film in inside magazines which lie side by side. It is very compact and light in weight. There are many master cinematographers who regard this as the finest product of the camera maker's art.

The work it produces is excellent, and a constant check is possible by use of a device which allows the operator to actually observe the image upon the film while the camera is in operation.

This camera is beautifully made of the finest materials. It is so arranged that instant and unobstructed access may be had to any part of the mechanism. There is nothing hidden away behind metal shields and enclosed in sealed

compartments. The camera is easy to clean and oil and should repairs be necessary, they are easily accomplished. For the man who wants a camera suited for general commercial and record work, and at the same time, one which will give satisfaction in the most exacting forms of trick work and special methods, this camera is to be recommended.

The specifications and illustrations will give full information regarding this camera.



The DeBrie Professional camera. This is a very compact and excellent camera.

The Andre DeBrie Camera

CONSTRUCTION—Wood or metal body optional.

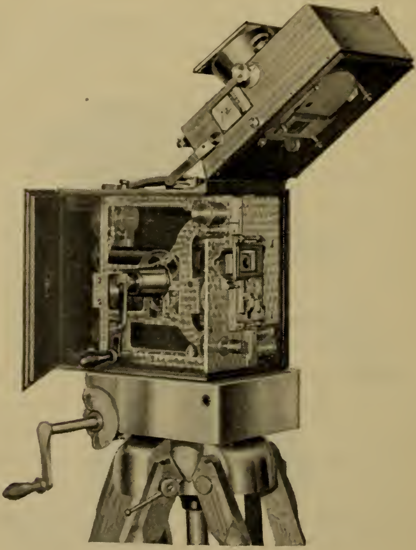
WEIGHT—Wood, 17 pounds, aluminum 20 pounds. SIZE 6 x 8 x 10.

CAPACITY—400 feet standard gauge film.

FINDER—Direct iconographic with range correction.

LENS EQUIPMENT—Optional. Change by bayonet joint. Lenses up to 20″ focus accommodated.

SHUTTER—Standard rotary adjustable with automatic dissolve (without dissolve at buyer's option).



The interior of the Debrie camera, showing arrangement.

INTERMITTENT—DeBrie special gear movement. Excellent.

MAGAZINES—Round, metal, inside, side by side.

TAKE-UP—Positive clutch, inside.

MOVEMENTS—Normal, single, reverse.

FILM METER—Dial on rear of case.

FOCUS—Scale and direct upon film by tube at rear.

FOCUS AND STOP ADJUSTMENT—By rod, visible from rear. Positive.

SPEED INDICATOR—At rear of case.

PUNCH—Rear of case.

REMARKS—A simplified topical model is made without the refinements which is excellent for topical work. Both studio and topical models may often be purchased at remarkably reasonable prices.

The Askania Camera (DeBrie type)

CONSTRUCTION—All metal.

FINDER—Newtonian with range correction.

OTHERS—Same as DeBrie.

REMARKS—This camera has an optical finder with lens and focussing screen, with range adjustment. It also has as a separate attachment a range finder which indicates distance of subject. The inside mechanism is protected by metal shields which may be removed by turning small catches. Thus when the camera is opened the mechanism is not subjected to the action of dust and grit. It is supplied with a full assortment of accessories at small cost. In fact a most complete outfit can be purchased for two thousand dollars which is the cost of a bare camera of some other makes.

The Ernemann Model E (DeBrie type)

CONSTRUCTION—Wood.

SIZE—6 x 8 x 11.

WEIGHT—15½ pounds.

DISSOLVE—Hand only.

FINDER—Newtonian with range correction.

REMARKS—For other specifications see DeBrie.

The Ernemann is a simplified model and cheaper than the others. Considering prices, there is really little choice between any of this group.

THE PATHE CAMERA

The pioneer studio camera is the Pathe. This camera is rarely used now, but many older instruments are giving excellent service. The principal objection to the Pathe is that it has the bulk and weight of the most complex camera, yet it lacks the refinements. However, the camera is extremely inexpensive for a studio model. The specifications will give full information.

CONSTRUCTION—Wood, leather covered.

SIZE—Without magazines, 4¾ x 8 x 12.

WEIGHT—22 pounds.

CAPACITY—400 feet standard film.

FINDER—Hooded Newtonian.

LENS—Optional.

SHUTTER—Adjustable, auto dissolve optional.

INTERMITTENT—Original Pathe harmonic cam.

MAGAZINES—Square, leather covered, outside unit type.

TAKE-UP—Spring belt, visible.

MOVEMENTS—Normal, single, reverse.

FILM METER—Dial and Veeder counter.

THE UNIVERSAL CAMERA

Among the smaller cameras which are suited for studio type of production on a smaller scale, is the Universal. This camera is favored by a great number of commercial cinematographers.

CONSTRUCTION—Wood and metal combination.

SIZE—4¾ x 11 x 12.

WEIGHT—21 pounds.

CAPACITY—200 feet standard film.

FINDER—Newtonian, hooded.

LENS—Optional.

FOCUS—Scale or direct.

SHUTTER—Adjustable, auto dissolve optional.

TURRET—To carry three lenses, optional.

INTERMITTENT—Universal harmonic cam.

GEARS—Steel and bronze.

MAGAZINES—Square, inside, metal unit type.

TAKE-UP—Positive clutch.

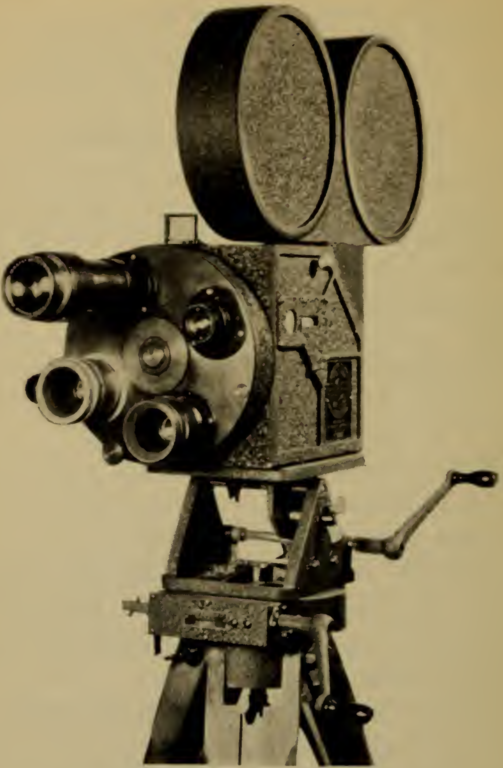
MOVEMENTS—Normal, single and reverse.

METER—Feet and frame.

REMARKS—This camera may be fitted with the mask box, outside iris and other usual effects. It is a very good instrument.

THE INSTITUTE STANDARD CAMERA

For some time there has existed a demand for a studio type of camera which would produce the



The Institute Standard Professional camera. This is a unit camera. That is, the simple unit is supplied to which accessories may be added at any later time. The illustration shows the camera with turret front, 3 extra lenses, 400 foot horizontal magazines and de luxe finish.

Although one of the most inexpensive cameras on the market today, this camera has been used and approved by news photographers, travelers, scientists, educators and manufacturers in all parts of the world. It has most of the features of cameras costing ten times as much.

finest film quality, which would resemble the most expensive cameras, which would be capable of complex trick work, which would be small and light, which would use standard film and which should be reasonably priced. To produce such a camera was a very difficult thing, but finally it was produced. The design is the result of the efforts of Mr. Carl Louis Gregory, the Dean of Cinematographers of this country if not of the world, and a Fellow of the Royal Photographic Society of Great Britain. Mr. Gregory was assisted by Mr. William Nelson and by the writer of this volume. This camera was sponsored by the New York Institute of Photography and manufactured in the factory of the Wilart Cinema Corporation. By thus combining the leading spirits of the various fields, the miracle was accomplished and the Institute Standard Camera is now upon the market.

The specifications of this camera are:

CONSTRUCTION—All metal finished in crystal enamel.

SIZE—Without magazine 6½ x 6½ x 7¾.

WEIGHT—16 pounds.

CAPACITY—200 or 400 feet standard film.

FINDER—Newtonian. Range finder optional.

LENS—Optional.

TURRET—Four lens capacity.

FOCUS—Scale or direct with magnifier.

SHUTTER—Fixed or dissolving optional.

INTERMITTENT—Wilart harmonic cam.

MAGAZINES—Metal, double, outside. 200 and 400 foot capacity interchangeable, set either obliquely or horizontally upon the camera body.

TAKE-UP—Spring belt, visible.

MOVEMENT—Normal, single, reverse.

METER—Footage dial Veeder counter optional.

REMARKS—This camera is remarkable in that it is of the unit type. The cinematographer may buy the simple camera, and then from time to time he may purchase the range finder, the horizontal magazine block, the turret front, the dissolving shutter, larger magazines and so forth. These may be attached by the owner and do not require factory fitting. All usual masks and outside effects may be secured. A hand dissolve of the iris type is supplied.

This camera has had a severe test and in the hands of cinematographers all over the globe it has proven its worth. Travelers, explorers, veteran news men and other expert cinematographers have used it and pronounced it good. The ships of the United States Lines have adopted it as the standard camera for their photographers, yet the simple model may be purchased for as little as one hundred dollars!

Chapter Five

PORTABLE CAMERAS

Attempts have been made for several years to build a camera which could be successfully operated without a tripod. As is usual in such a development, many models were produced which were totally impractical and even ludicrous. The great fault of these early experimenters was that they could not free themselves from conventional ideas, and they tried to adapt the professional camera with its 400 foot magazines and all adjustments to this purpose. The motors were either electric or compressed air drive, neither of which is simple enough for this purpose.

One of the best and most favorably known of the world's motion camera manufacturers produced the first practical automatic camera. This was the Sept camera, made by Andre De-Brie in Paris. This camera is a beautiful instrument which gives perfect satisfaction. The only criticism of this camera is that its capacity is limited to seventeen feet of film. However, in many hands this is a decided advantage. Amateurs are inclined to drag their scenes out too long. The amateur will not encounter one time in a hundred a scene which really necessitates a longer period than fifteen seconds. The short, peppy scene makes the best films.

Unfortunately for the manufacturer and fortunately for the amateur, the small cameras

were introduced shortly after the Sept was, and their popularity practically killed the American market for the Sept camera. Consequently these fine cameras which sell for two thousand francs in Paris to-day, can be purchased in America for fifty dollars or less. They are beautiful instruments and worth every cent of their original price.

The Sept camera. This is an automatic camera of 17 feet capacity and now used almost exclusively for making "film lantern slides" that is single exposures on motion picture film for projection in special projector. This work makes up a very good side line for the cinematographer.

Soon after this, the Ica Company (Now Zeiss-Ikon) brought out the Ica Kinamo. This camera, in its hand cranked form, was already familiar to the public, and the new model was well received. Here for the first time we have an automatic camera using standard gauge film and fully automatic which has also an adequate

capacity for semi-professional work. At the same time we have a camera of 50 foot capacity, complete with clockwork motor, whose size is only from one-half to one-fourth that of any ordinary, hand cranked 100 foot model camera.

The Zeiss-Ikon Kinamo Camera

Zeiss-Ikon Kinamo

SIZE—About 2 x 4 1/4 x 6 (without motor). The motor is the same size as the camera and about 1 3/4 inches thick.

WEIGHT—3 lb. 4 1/2 ounces.

CAPACITY—50 feet standard gauge film.

MAGAZINE—Double, inside, metal.

METER—To 15 meters of film by single meters.

FINDERS—Iconometer finder on camera, direct view finder built into motor case.

LENS—Carl Zeiss Tessar, focus 40 millimeter, either f 3.5 or f 2.7.

MOTOR—Capacity of drive, up to 20 feet with one winding, built in direct view finder. Optional equipment—range finding device for finder, focussing scale visible in finder, self portrait apparatus which holds up release of spring for a half minute allowing operator to get into picture before the action starts.

ZEISS-IKON KINAMO-80 foot model.

SIZE—About 2 1/4 x 5 1/2 x 6 inches

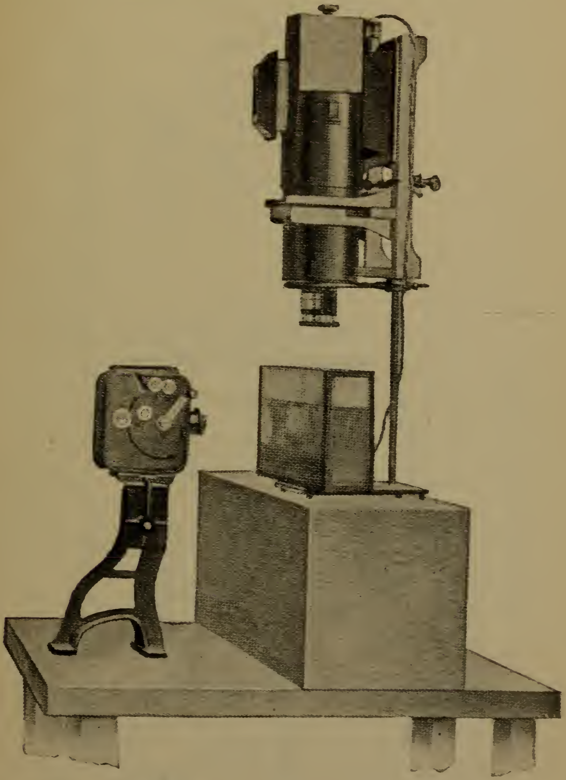
Other specifications as above except capacity which is 80 feet of standard film. Can be supplied with same motors as above.

Zeiss-Ikon Kinamo "Universal"

The Zeiss-Ikon Universal Kinamo greatly resembles the 80 foot kinamo, but it has been especially designed for scientific purposes. This camera has a special lens mount which facilitates rapid changes. Thus lenses can be changed, or special adapters may be used which enable objects at a close distance to be photographed. This attachment is also used in connecting the camera to the "Microphote," which is a specially designed photomicrographic camera for making microscopic subjects upon motion film.

The Universal Kinamo is also designed so

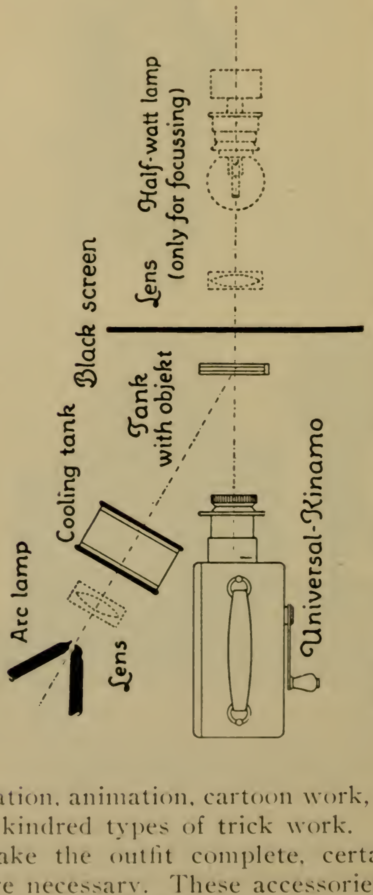
that it may be used as a printer, being provided with a special printing magazine, film slot and enclosed printing light. At this time the Uni-



The Kinamo camera being used
for making aquarium films

versal model has not been motor equipped because it is designed especially for that work where the motor would be useless.

The Universal Kinamo is the scientist's camera. It can be used with telephoto lenses or with the microscope. It is adapted for time

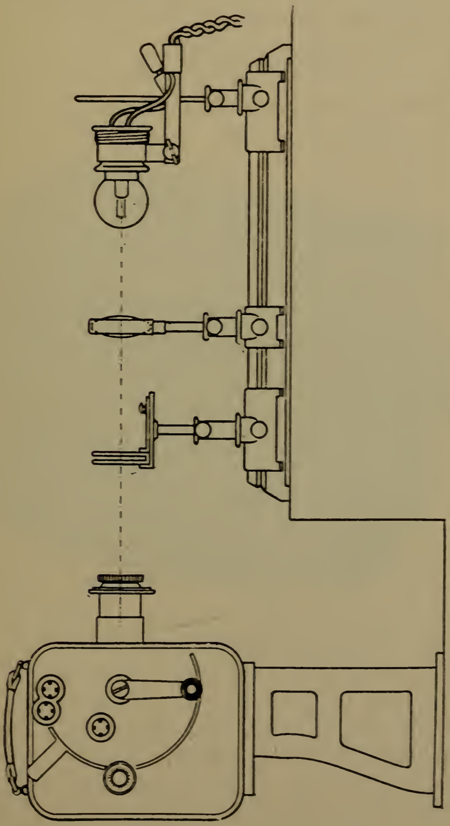


The Kinamo arranged for photographing small translucent objects

condensation, animation, cartoon work, title making and kindred types of trick work.

To make the outfit complete, certain accessories are necessary. These accessories include: Magazine for printing—lamp for printing—

adjustable laboratory stand for the camera—tripod with panoramic top— "Microphote" attachment for photomicrography—optical bench



The Kinamo arranged for photographing small transparent objects

—iris ring—lens holder—lamp holder—special lamp either arc or incandescent with proper rheostat—condenser lens—front lens adaptors

for near distances and 7 1/4 inches telephoto lens.

With this complete equipment the photographer is prepared to make practically any film required by the scientist.

DeVry Automatic

The DeVry Corporation is known all over the world in connection with motion picture projection. For years the portable projector made by this factory has been recognized as one of the best. As this company caters to the very class of users who would most appreciate a portable, automatic camera of good quality it was only natural for them to produce this camera. When the announcement was made, the motion picture public looked forward with great interest to the event. News cameramen and others who have to make exposures upon the shortest possible notice were particularly interested. When some emergency arises, the seconds occupied in assembling the outfit and in setting up at the scene of action, every one counts. Often the loss of a shot is the result of seconds lost. With this camera all that is necessary is to pick up a small, compact case, hurry to the job, swing the camera up before the eye and press the button. With an even start, the cameraman fitted with the automatic camera will scoop the rival operators by at least four or five minutes. And these four or five minutes will often be worth the total cost of the camera.

The camera is singularly attractive to the eye. It is of regular, rectangular shape, with rounded corners. It is beautifully finished in pressed steel with a leather texture embossed

in the steel. Fittings are nickeled. This camera has, in addition to the features given in the table of specifications, some refinements which make it particularly desirable.

The outstanding fault of such cameras is that many operators cannot hold the camera at eye level without having some movement which will make the picture "dance" upon the screen. This

The DeVry automatic, standard gauge camera as used in news work.

may be due to the nervousness of the operator or it may be due to the unbalanced pull of the driving spring.

Everyone who has had experience with spring driven mechanisms knows that the spring pull is not uniform. A spring does not unwind in a concentric path, but does so all at one side, so that when unwound the central shaft lies near

one side of the outer length of the spring. In the DeVry camera, two such springs are applied upon opposite sides of the shaft. Thus the two springs, while both driving the shaft, act in such a manner that uneven torsion is eliminated. The result is a smooth, uniform action. Thus the DeVry is completely equipped to give a picture which in steadiness will compare with the film from a tripod supported camera.

The DeVry camera has a direct finder of the usual type, but it also has a brilliant, reflecting finder. In addition the camera has two rings affixed into which a shoulder strap is affixed with snaps. In case an operator is nervous and cannot hold the camera firmly at eye level, he attaches the shoulder strap and allows the camera to rest firmly against his hip. This is one of the firmest positions a camera can be given. In this position the reflecting finder comes into service. Under such conditions, an absolutely solid rest with accurate finder, a steady picture can be produced.

One of the essentials of the portable camera is the reduction of weight and size gained by eliminating the magazines. With or without magazines, the motion camera must be capable of being loaded or unloaded in daylight. To accomplish this without magazines the "Daylight loading" film is used. This film is ordinary film with a "leader" and "trailer" of opaque film wound upon metal spools which have solid side flanges. The opaque film is wound onto the take-up spool after the camera is closed. When the film is fully exposed, the camera is operated for six or eight seconds longer. This winds the opaque trailer about the exposed film and pro-

tects it when the spool is removed from the camera.

This system would be entirely satisfactory were it not for the fact that at times the thin side flanges of the film spool get bent. Even a slight bending will close the two flanges to such an extent that the film will bind. If the film does not enter the spool freely, the increased tension will cause the take-up to slip and the result is that instead of winding smoothly and firmly, the film will wind loosely and may even pile up in the camera chamber. The DeVry camera has a flange gauge which indicates instantly the condition of the spool flanges, so that the spool can be tested before threading. This feature will save valuable shots.

Due to compact design, the lens mount of portable cameras projects its full length. As a very hard blow is not required to ruin a fine anastigmat, the lens is constantly endangered. The greatest danger is encountered in transportation, as the owner usually watches his lens while the camera is in use. Even a carrying case will not fully protect the lens in shipping. The DeVry lens is attached to the camera by a bayonet joint and it may be attached or removed instantly. Inside the camera there is a projecting boss fitted with three lugs which take the bayonet joint. Upon this boss is a nickeled cap which also has the bayonet joint slots. During transportation the lens is carried upon this boss inside the camera, while the mechanism is protected by the cap. In use the cap is carried inside the camera upon the boss.

In short every deficiency of existing types of cameras were studied so that they might be

overcome in this model. The success of the designers is proven by the fact that this camera has been widely adopted by professional news men, men who demand the best work from the least size and weight of mechanism.

The specifications are:

CONSTRUCTION—Pressed steel case—mechanism of steel and bronze. Case embossed with leather grain and black enamelled. Fittings nickeled.

SIZE—3 3/4 x 6 1/2 x 8 1/2 inches.

WEIGHT—9 pounds.

CAPACITY—100 feet daylight loading standard film.

FINDER—(a) Direct on film for titles, etc.
(b) Direct Newtonian on top of camera.
(c) Brilliant reflecting for low positions.

LENS—Equipped with 2", f3.5 anastigmat. Any lens may be fitted.

SHUTTER—Rotary disc, 135 degree opening, best for general work.

INTERMITTENT—Double, uni-lateral claw with "D" guide.

TAKE-UP—Positive, inside. Ball bearing.

MOVEMENTS—Normal by automatic spring drive. Any desired by hand crank. Crank serves as winding key for spring motor. Forward only.

METER—Dial on top of camera.

FOCUS—Scale or direct by reflecting device in camera.

MOTOR—Double spring, starts and stops at full speed. May be locked in operating position allowing operator to get into picture. 55 feet per winding.

CASE—Carrying case covered with hand boarded leather. Full velvet lined. Takes camera with lens inside, 3 extra spools film, camera shoulder strap, case strap and hand crank.

TRIPOD—Any fairly heavy tripod or light motion picture tripod. One tripod socket in camera fitted for standard M. P. thread.

THE EYEMO

The first venture of the firm of Bell and Howell into the non-studio field was the introduction of the Filmo camera using sixteen millimeter film. So popular was this camera, that the Eyemo was introduced. This camera is a big brother to the Filmo, using standard film.

The Eyemo camera, like all B & H models, has a case built to conform in shape to the enclosed mechanism. The principal body is a long oval, the rounded ends conforming to the shape of the film spools. At one side is a round chamber containing the motor, and in front is a similarly shaped compartment which contains the shutter and upon whose front plate is mounted the lens. The space between the film chambers contains the aperture plate and film driving mechanism.

The remarks already made regarding the efficiency of the automatic camera apply to this as to other cameras of similar type.

One of the outstanding features of this camera is the variable drive. By moving a small lever

the film speed is changed from sixteen per second to eight per second. This may be done while the camera is in operation. Another is the visibility of adjustments. The finder is a tube-like appliance attached to the side of the camera. As the operator looks into this tube he can see

The Eyemo, the Bell & Howell automatic, standard gauge camera

the full field of view and at the same time the diaphragm scale, the focussing scale, the film meter and level are visible. This allows a constant check upon adjustments.

For convenience in holding, a sturdy handle is supplied which is fitted with a hand strap. This strap is looped about the right wrist and aids materially in holding the camera steady. When this handle is removed the camera may be mounted upon a tripod.

The specifications of the Eyemo are:

CONSTRUCTION—All metal, finished in crystal lacquer.

SIZE—4 1/2 x 6 x 8 irregular shape.

WEIGHT—7 pounds.

CAPACITY—100 foot spool standard daylight loading or 120 feet dark room loaded film.

FINDER—Optical with removable objective to match camera objectives.

LENS—47 m/m, f 2.5 anastigmat supplied. Any lens may be fitted.

SHUTTER—Rotary disc 170 degree opening.

INTERMITTENT—Bell & Howell special.

TAKE-UP—Positive, inside.

MOVEMENTS—Normal and half normal varied at will.

METER—On side of camera, visible in finder.

FOCUS—By scale.

MOTOR—Heavy duty, 35 feet per winding. Key wound.

CASE—Cowhide to contain camera, six rolls film and accessories.

TRIPOD—None required. Any light form may be used.

There can be no fair comparison between the portable camera and the studio camera. You cannot ask a man whether he prefers a passenger automobile or a truck. His choice would depend upon his business. Just so with the cameras. Each type is made for a specific pur-

pose, and in many cases one purpose will not be served by the wrong type of camera. The efficient commercial photographer will equip himself with two cameras, one studio model and one automatic drive camera. Only in this way can he be prepared to meet all emergencies. If the choice is limited to one camera the choice must depend upon the kind of work to be done.

As to the price class. Any of the cameras described will give the utmost satisfaction. More money means that the purchaser will not receive better results, but that he may secure certain refinements not found on cheaper models. However, even price is no criterion of quality and refinement of design. The only worth while advice which can be offered is that the prospective purchaser study the descriptions of the cameras and then purchase the one best fitted for his purposes.

There is one thing, however which should be regarded. If funds are limited, the commercial motion photographer would better purchase two of the more inexpensive models described, one studio and one automatic, than to buy a single, high-priced instrument.

A careful study of the opportunities at hand and of the instruments themselves will make a choice fairly easy. Every camera described has been widely used and has proven satisfactory. Each owner thinks that his own individual camera is best. So at last the choice lies with you.

Chapter Six

SUBSTANDARD CAMERAS

The idea may have been given that the substandard cameras are not to be seriously considered. The contrary is the case. In fact, it is only a question of time until the substandard cameras and projectors will be universally used for practically all non-theatrical purposes. The standard cameras are better fitted for some complex studio operations, but the substandard cameras are being constantly improved and before long we will no doubt have the complicated small instruments which will in every way duplicate the work of the standard cameras, but the principal goal of the substandard manufacturers at this time is simplicity, ease of operation and assured results. These ideals have been realized to a truly remarkable extent, and at this time, hundreds of business men have adopted the use of the substandard films and projectors in their businesses, although in many cases if not in most the camera used in this particular type of work is the standard camera.

There is a wonderful opportunity at this time for the amateur and commercial cinematographer to cash in on the vogue of the small camera. He has before him film sales, camera sales and projector sales.

The substandard camera was made possible in the first place by the introduction of the 16

millimeter film, and for this we must thank the Eastman Kodak Company, while the only serious rival of that company, Pathe of Paris, followed suit almost immediately with their own 9½ millimeter equipment.

The first Cine-Kodak was the hand cranked Cine-Kodak A. This camera, for some unknown reason, did not meet with wide approval. It was a well designed, beautifully made instrument and was equipped with a motor drive as optional equipment. Following this was the Cine-Kodak B which is becoming almost as common as the still Kodaks. The model B is the type of camera which will appeal instantly. It is small, light, motor driven, of good appearance, simple to operate and gives good results.

Cine-Kodak B

CONSTRUCTION—Metal, covered with morocco leather.

SIZE—About 8¼ x 5½ x 3 inches.

WEIGHT—5 pounds.

CAPACITY—100 feet 16 mm., film.

FINDER—2 provided, direct and brilliant reflecting.

LENS—Optional, f 6.5, f 3.5, f 1.9 or telephoto

SHUTTER—Standard, fixed, rotary.

INTERMITTENT—Special Kodak.

TAKE-UP—Positive, inside.

METER—Registering in feet

FOCUS—Universal focus or by spiral mount.

MOTOR—Built in with crank attached permanently.

EXPOSURE GUIDE—Attached to front of camera.

CASE—Black leather.

TRIPOD—None required, but any light metal tripod may be used.

The 100 foot spool of 16 mm., film is equivalent to 250 feet of standard gauge film. The film costs a trifle more **per foot** than does standard, but this first cost is the whole cost, and as the film is equivalent to 2½ times its actual footage, the final cost for the picture upon the screen is roughly 25% of the cost for a similar standard film.

This camera is proving very popular and fills the same need that the Kodaks fill, a good, dependable, fool-proof camera which may be used day in and day out without trouble.

Filmo Camera

The name of Bell & Howell is familiar to all readers of motion picture literature. They manufacture the world's standard motion picture camera, used in the production of about 95% of the world's professional, theatrical films. Needless to say, they have had plenty of experience in the field of motion picture engineering. This

experience was utilized in producing their first 16 mm., camera, and the Filmo was the result. The design of the Filmo brings up a point concerning the comparison of the various small cameras. There is little if any competition in this field of small cameras. Each meets a definite need, and there are some amateurs who own and use all three of the most widely known

The Bell & Howell Filmo, 16 mm. automatic camera, which is modeled upon the same lines as the Eyemo

cameras, i. e., Pathex, Kodak and Filmo. Each has a definite place which cannot be filled by either of the two others, and the choice of the owner will depend upon his requirements.

The Bell & Howell camera, the Filmo, is made in accordance with the traditional Bell & Howell quality, than which no more can be said in praise. It is well built, well designed, presents an attractive appearance and does good work. It is built along unsymmetrical lines, the

housing conforming to the form of the enclosed mechanism. While quite expensive, these exclusive features make it well worth its price; interchangeable lenses, diaphragm and focussing scales visible in the finder, B & H patented finder tube, and the truly amazing line of accessories which make it very flexible, such as color filters, iris vignetter, extension finder for telephoto lenses, focussing magnifier for direct, visual focussing of the lens, and so forth.

The Filmo specifications are:

CONSTRUCTION—Metal, crystal black enamel.

SIZE—About 2 x 6 x 8 irregular shape.

WEIGHT—4½ pounds.

CAPACITY—100 feet substandard 16 mm., film.

FINDER—B & H special optical type.

LENS—Optional from 20 mm., to 6 inch focus, from f1.5 up in speed.

SHUTTER—Rotary, 216 degrees opening in one model, 180 degrees in others.

INTERMITTENT—Bell & Howell special.

TAKE-UP—Fixed, positive, internal.

METER—Registering in feet.

FOCUS—Universal focus lens, interchangeable with lenses which are focussed by scale or visually by the focussing magnifier.

MOTOR—Built in, spring power.

CASE—Several types optional.

TRIPOD—None required, but any good, light tripod may be used.

The Filmo is supplied in three models. One of these models has a changeable speed of either 8 or 16 frames per second, a second model may be operated at 12, 16, or 24 frames per second while a third model has a fixed speed of 128 frames per second, for slow motion effects only.

The Filmo camera is universally used and has been carried on several scientific and exploring expeditions as well as being used by many celebrities for their personal use.

The Cine-Kodak is the truly Kodak type of camera, it is the picnic and vacation camera for the man in the street who wants to make souvenir films to bring back with him. It is no more troublesome to carry and use than the ordinary postcard size Kodak. In this camera the Eastman Company have carried out their ideal of "Push-the-button" simplicity.

The Filmo is the substandard camera ideal for the hunter, the explorer and the scientist who so often must either secure film from a great distance or lose it entirely. More than anything else, the telephoto lenses have made Filmo invaluable to this type of owner, and it has never failed to "bring home the bacon."

We now come to the camera which is not a special occasion instrument, but which can actually be carried habitually, always ready for instant use, yet never obtrusive. With almost unbelievably small bulk and weight, it nevertheless produces results which are comparable in every way with those produced by other substandard cameras. This is the Pathex camera, which may be used with or without the motor drive as the occasion may demand.

Pathex Camera

It can be readily understood that in determining the gauge of any new motion picture film, the size of the frame is the primary consideration, for after all it is from the frame and from the frame only that we secure the projected image. All film not used in the frame area is used only as a vehicle of transmission through the mechanism.

In the case of the 16 millimeter cameras, we use a film which has a frame measuring approximately 7½ x 10½ millimeters, the actual size varying slightly with different cameras, and still further altered by the apertures of the various projectors. This film has one constant factor, that is it has a frequency of 40 frames per foot, or 2½ times the frequency of standard film which is 16 to the foot. With a frame of 7½ x 10½ millimeters and a frequency of 40 to the foot it was necessary to add sufficient body to the film to permit perforation for the usual sprocket transmission. This addition increased the width of the film ribbon from 10½ to 16 millimeters.

When the oldest film company in the world, Pathe Freres, entered the substandard field, this problem was attacked from a different angle. They too established a frequency of 40 frames to the foot, 2½ times standard, so that in this respect the 16 and the 9½ millimeter films are identical. Desiring a frame more nearly square, which would permit easier, coincident composition of both vertical and horizontal lines, the frame was cut down in width to the extent of 2 millimeters, making the actual frame measure

7½ x 8½ millimeters. The perforation was made in the center of the film midway between frames, the only device allowing a perfectly straight pull with a single claw. This allowed the physical body to be reduced considerably with the result that ½ millimeter was added on each side to provide edge support, and thus a frame 8½ millimeters wide was secured on a film whose total width is only 9½ millimeters. This is but one of the unique advantages of the Pathe **Pathex** substandard equipment.

Both camera and projector are the smallest practical motion picture apparatus made. The projector will be discussed fully in the chapter given to projectors, but a few points may be mentioned here. The actual film footage is reduced about 30% by the use of a patent automatic stop title mechanism which places each title on one, two or three single frames and stops the film at these points without having the actual projector mechanism stopped. In addition to titles, many shots which include little or no action may also be shown still greatly increasing the projection time for a given reel. The writer has one 30 foot reel in his possession which runs approximately fourteen minutes, or only slightly less than the usual 400 foot, 16 millimeter reel. This mechanism is operated by small notches cut in the edge of the film by means of a special punch provided with the projectors.

Neither camera nor projector use sprockets, the claw feed mechanism and the ingenious take-up being so designed that a perfect film feed is secured without troublesome sprockets. This greatly facilitates threading, with the result that the

exposed magazine can be removed in two seconds and a fresh one placed in the camera in five seconds, actual stop watch time. There is no threading. To load the camera the magazine is dropped into place and the door closed, to remove it the door is opened and the magazine lifted out. The projector is as simple as will be seen.

The camera takes 30 feet of film at one load. This is an ideal length, serving for three short shots, two medium, one long and one short or one very long shot. There is no waiting to fill a long reel before development, the size and weight of the equipment is reduced, while the quick load feature makes possible a practically continuous operation.

These features, with the device which makes it possible to make your titles right at the time of shooting, eliminating just so much edition, the light weight and small size have induced many owners of 16 mm. equipment to add a Pathex to their equipment, as a camera to be carried habitually.

Due also to its portability and the fine results which it produces, Pathex has been chosen by many film and other celebrities for their personal use, both in travelling and at home

Pathex Camera

CONSTRUCTION—Metal, morocco, nickel trim.

SIZE—With motor attached 3″ wide x 3⅜″ deep x 4½″ high. Without motor the width is reduced to about 1½ inches.

WEIGHT—With motor attached 3 lb. 6 oz.

CAPACITY—30 feet 9½ millimeter film in Pathex magazine.

FINDER—Iconographic showing exact field.

LENS—20 millimeter, f 3.5 cine anastigmat.

SHUTTER—180 degree rotary disc.

INTERMITTENT—Pathe harmonic cam, single central claw.

The Pathex Camera. This is the smallest practical motion picture camera made.

TAKE-UP—Positive enclosed type.

METER—Up to 1200 individual frames.

FOCUS—Fixed focus.

MOTOR—Attachable and detachable at will, allowing use of hand crank at any time. Motor release may be latched in operating position allowing operator to get into picture.

CASE—Heavy leather, to take camera, motor and 4 extra magazines of film.

TRIPOD—None required, but any good quality, light, metal tripod will serve.

With the Pathex as with the 16 millimeter cameras, the first cost of the raw film includes developing costs and return mailing charges. When you buy the film you pay for everything. The exposed film is mailed in the original carton to the laboratory where it is finished and returned to you, prepaid, with no further charge of any kind.

Chapter Seven

THE MOTION CAMERA IN USE

While the designs of various cameras differ considerably, the basic operation is the same with all. We have seen that the motion camera has a mechanism which pulls the raw film from the retort, and which feeds it into the first loop. Then we have the intermittent mechanism which pulls the film past the exposure aperture in the gate, yet which allows the film to remain stationary while the actual exposure is being made, and finally we have the mechanism which takes the exposed film from the lower loop and feeds it into the take-up magazine. Thus we find that in loading the camera we have to pull about two or three feet of film from the retort, pass it under the first sprocket guide rollers, through the gate, under the second guide rollers, and into the take-up magazine. In some cameras this procedure is followed just as stated. In others, using a double magazine, the film is attached to both retort and take-up spindles in the darkroom, and threading is accomplished by pulling a long loop from the magazines. This is the procedure when using the Institute Standard camera. Still other cameras have no magazines, but use daylight loading spools as in the case of the DeVry camera. Here we pull out the paper leader and use it for threading, or as some spools have a dark film leader, we use it. At any rate in such daylight spools, we do not expose any of the sensitive film to daylight.

We see that in the threading, each camera requires different handling, so the best thing to do is to carefully follow the maker's directions which accompany the camera. With a length of dummy film, practice threading until you are thoroughly familiar with each step in this procedure. The all-important thing is to see that the loops provide sufficient slack film to allow the intermittent to work freely, but not enough to allow the sensitive emulsion side of the film to touch the inside of the camera. Next in importance is to see that there is no looseness in the film between the lower sprocket and the take-up. If a loop is allowed to form here the film will probably become entangled with the sprocket or with the magazine mouth and pile up in the camera. This ruins the film and endangers the mechanism.

When threading is completed, turn the crank once or twice, or just touch the release button, to see that the film runs smoothly before closing the camera. The camera is then closed and you are ready for your first shot.

In making the exposure, you have to select a position in reference to your object which will insure the proper light direction, you have to place the camera so that the proper field of view is included, you have to focus the lens properly, and you have to determine the proper exposure to give.

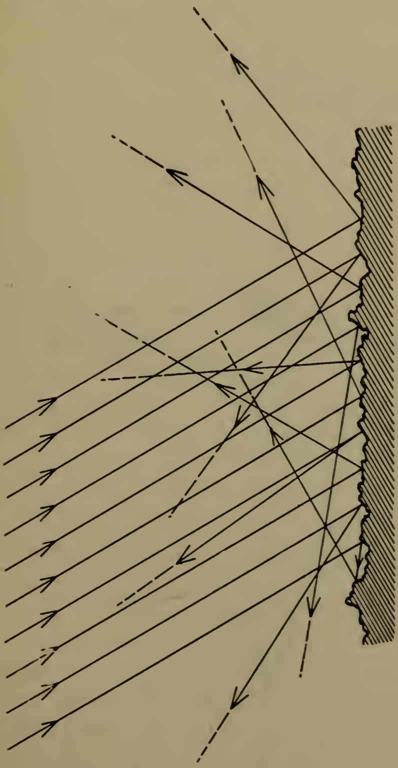
In the case of studio and other interior work, the light is under control, but this work will be dismissed until later. In most cases when the work is exterior, the position of the camera is determined by the position of the sun and of the subject. When the subject may be moved, it is placed properly first, and then the camera is set

up. When the subject is immovable, the exposure is delayed until the light is right, but when the exposure has to be made at a given time, regardless of the time of day, the camera must be so placed as to give the most effective compromise between position of subject and sun.

When the subject is under control, the best general lighting is that which places the sun at the side and slightly to the rear of the cameraman, with the light falling obliquely upon the subject. Thus exposures during the hours near noon are to be avoided. A sun directly at the back of the cameraman will give a flat lighting. We see all objects in three dimensions, but that effect which, more than anything else, enables us to see depth is the play of light and shadow upon an irregular surface. If we see a sharp patch of shadow, we know that some portion of the object lies between that shadow and the sun. This is true of faces and figures. A light falling at an angle, gives us shadows which help us in interpreting the form of the subject. If the light falls directly upon the subject, i.e., from the rear of the cameraman, such shadows are reduced to a minimum, in consequence we have difficulty in perceiving depth and we have the flat lighting. So striking is this effect, that we have come to use the word "flat" for all photographic reproductions which are lacking in contrast.

However, in most cases of subjects posed in direct sunlight, especially close-up subjects such as people, we find that the contrast is so great between the light and the shadow that we get pure white patches for the light areas, solid black for the shadows and no detail in either. The fact is that no photographic emulsion is capable of

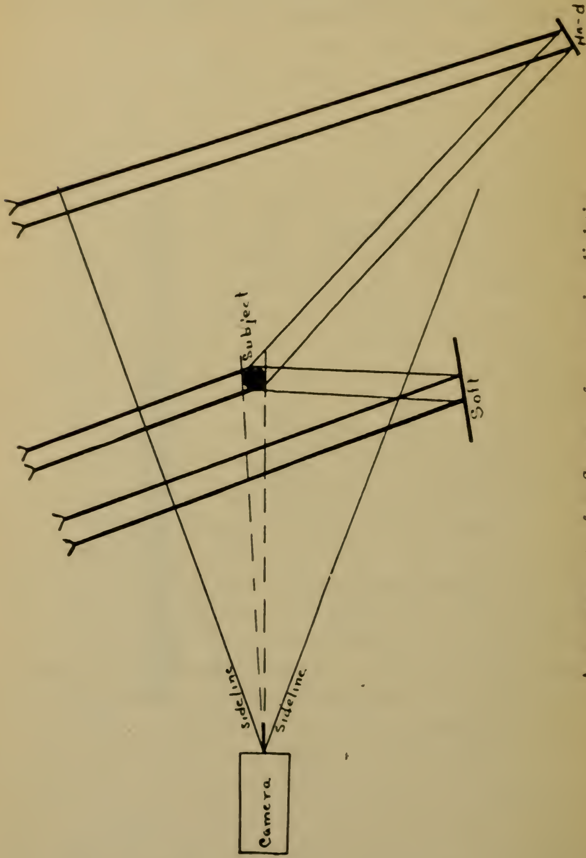
reproducing the scale of contrast visible to the eye. This means that we must effect a compromise. To do this, the simplest way is to make the exposure in dull light. At times it is neces-



How light is reflected from an unpolished surface. This accounts for the diffused or "soft" light given by a reflector covered with flat drying paint.

sary to make the exposure in bright light. In such case we find that reflectors are of immense advantage. These reflectors are large screens, hinged in the middle. In size they may range

from two feet square to ten or twelve feet square. A practical size is four feet square, hinged so



Arrangement of reflectors for exterior lighting

that folded they measure two by four feet. They are made of pieces of wallboard nailed to wooden frames. The surface is then painted with (a)

flat white paint for soft lighting (b) white enamel for medium lighting or (c) covered with tinfoil for hard lighting.

The subject is posed in the sunlight, then the reflector is placed in such a position that the side of the subject away from the sun is illuminated by light reflected from the surface of the reflector. In this case the intensity of the highlight remains unchanged, but the shadow area is considerably lightened, thus reducing contrast. In this case the camera diaphragm must be closed somewhat to compensate for the unusual amount of light falling upon the subject.

In the case of news work and in similar cases where such controls are impossible, the camera position is selected which will give the smallest possible amount of shadow area without securing a fully flat lighting. A fully lighted subject with narrow shadow bands is far preferable to a deeply shadowed subject with narrow bands of intense lighting. In this case the sun should be about fifteen degrees distant from a point immediately at the rear of the camera.

Unusual lighting effects should be used with care. While they are most effective in studio production where every factor entering into the production is under full control, they often react disastrously in the hands of the commercial and amateur cameraman. For the man versed in ordinary photography it is enough to say that he should stick to the lightings with which he is familiar, always remembering that the intensity must be sufficient for instantaneous exposures.

The question of interior lighting is quite another story. Here we choose the positions of subject and camera and then place the lights to

conform to these positions. Interior work is always more satisfactory than exterior because of this light control. Here we can place our lights at one side or another, high or low, and we can

The Wohl Duplex arc in a funnel for hanging from the ceiling. This lamp giving 19,000 candlepower at 25 amps is one of the best "high" lights made, especially when equipped with the funnel shaped reflector shown here.

balance a strong light with a weaker. We use spots for accentuation and in fact we literally "paint with light."

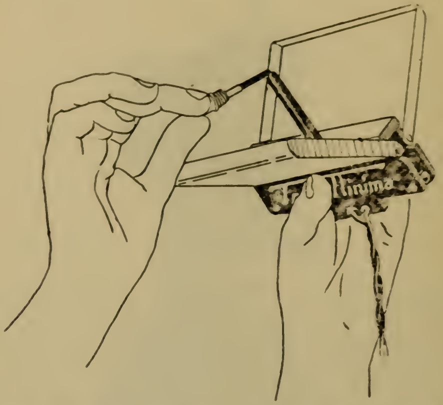
In this work we may use incandescent lights, mercury arcs, magnesium flares and arc lights. The incandescent light necessitates an immense

number of bulbs of high wattage which makes a heavy drain upon the lighting circuit. The mercury arc gives a beautiful soft effect, but here also we need the lights in banks of six or more,

The Cameralite. This is one of the most recent introductions in the field of portable arc lights. This camera is made of sheet steel, enameled in an attractive black crystal finish. It uses special star-core carbons, which with the patent Wohl circuit allows a 12,000 candlepower at an absolute maximum current of ten amperes. The light may be safely used with ten ampere fuses, which is not true of all lamps rated at ten amperes. This lamp while rated at 8,000 candlepower for covering an area of 14 square feet, will actually deliver as high as 12,000 C. P. and in the writer's hands has sufficiently illuminated an area of thirty square feet for the use of an f 3.5 lens at full crank speed. The complete lamp measures 3½ x 6 x 11 inches and weighs six pounds. Its tremendous power and the fact that it very closely resembles a roll film camera when closed has made this lamp a great favorite although only recently introduced.

and this means a heavy initial expenditure and heavy electric drain. Magnesium flares are expensive, dangerous, smoky and are used only in making outdoor shots at night or in locations where no electric current is available. The arc

light provides us with an intense white, highly actinic light with a comparatively light electric drain. In fact we can use two of the small portable twin-arcs in any ordinary dwelling without endangering the electric installation, and this



The Traut Minima arc light. This is the smallest arc light yet produced. The carbons are about ⅛ inch in diameter, yet they are cored and give a brilliant white light. This little "Pocket" arc will give about 5,000 to 8,000 candlepower, and closeups can be made with the usual motion picture camera at normal speed with one of these lights. (Courtesy Bass Camera Company.)

provides plenty of illumination for semi-closeups. With a fast lens, say f 2.9, we should be able to cover an area of about six by eight feet and four feet deep with entire satisfaction. Thus we can illuminate two or three figures satisfactorily, while the surroundings, which are more dimly seen, only serve to accentuate the figures and do not detract from the picture. In the case of factory interiors and similar subjects, where

full illumination is required, a battery of ten or a dozen twin arcs will be required.

A spot light will also be needed in almost every case. This may be a small portrait lamp

The Wohl Hi-Speed twin arc light. A high powered twin arc giving up to 36,000 candlepower on 35 amperes of current.

using an incandescent bulb, or it may be an arc. This will depend upon circumstances. In many cases its illumination is added to the existing illumination so that it need not have excessive power.

For many subjects, back-lighting has been found to be most effective. This simply consists of throwing an intense light upon the side

The Wohl arc spot-light. This is a type of spot used for accent lighting in studio production.

of the subject away from the camera from a hidden source of light.

This lighting should be intense as its effectiveness depends upon halation. The hair especially refracts the light to such an extent that the

subject seems to be surrounded by a halo. This effect is secured outdoors by reflecting the sunlight from a mirror, and indoors by use of a high-powered spot light. It serves to accentuate the subject and to set it apart from the background.

Other unusual lighting effects are secured by placing the principal source of light in front of and above the subject or in front of and below the subject. The first position gives a sinister expression to faces while the second gives a weird and fantastic appearance to the whole scene.

In judging the effect of the light it is well to look at the lighted subject through a blue filter. This will show the approximate effect which will be shown by the film itself.

When the lighting has been arranged to the best advantage, that is, when it lights up the principal objects and gives the effect desired, the next step is to set the camera. The cameraman walks about until he sees the approximate effect which is desired. The camera is then set up where he stands. Now the scene is observed in the finder or upon the film as the case may be. When this is done, it will be found that the effectiveness of the scene may be increased by moving the camera slightly to one side or the other. Then it may be that there is too much foreground or not enough. This is remedied by lowering or raising the camera slightly. The higher the camera the more the foreground will be in evidence and vice versa.

In all except fairly long shots the finder should be checked to see how nearly it reproduces the field of the taking lens. The camera should have the finder mounted on the same level as the lens

and have some arrangement whereby the optical axis of the lens may be set at an angle to the optical axis of the lens so that in closeups the two fields will coincide. If an optical finder is used it should be swung upon a pivot for this purpose. If the Newtonian finder is used, it should have a series of eye holes, or a sliding eyepiece so that the line of sight may be made to converge with the lens axis. If this is not done the finder will not show the true field on closeups and the film will have the subject decentered.

When the proper angle of view is secured, the lens must be focussed. This is a critical operation and much of the effectiveness of the subject depends upon the proper focus. It is always best to focus directly upon the film or upon a piece of ground film placed in the aperture. In the case of the Bell & Howell professional camera this may be done by the special sliding arrangement of the camera without fogging any film.

In filming mechanical subjects, record subjects and similar non-pictorial and non-dramatic subjects, a needle sharp definition is desirable throughout the field. This means that the illumination must be of such intensity that an iris aperture of f 11 or smaller may be used, although f 8 may be used if care is taken in the focussing. Remember that the smaller the iris aperture the sharper the detail.

In landscape work, there is always one object of principal interest. This object should be sharply focussed. The set up should be such that no foreground is shown closer than fifteen or twenty feet from the camera. A fuzzy fore-

ground is inexcusable, although it may be slightly soft in focus. In photographing distant scenes, use the small stop for universal sharpness, but for objects in the middle distance and foreground, open the lens to f8 or larger. This will soften the distance and provide atmospheric depth.

In filming people, focus sharply upon them and let the background go fuzzy. This will prevent extraneous objects in the background from spoiling the effect of the picture. This process of using out of focus planes for securing pictorial effects is known as differential focussing. Naturally it cannot be used unless the camera has an adjustable shutter. With fixed shutter cameras, the iris is set to give the proper exposure and no other setting can be used.

This brings us to the consideration of giving the proper exposure. There is no more important single factor in photography than exposure. The quality of the resulting negative is directly proportionate to the accuracy with which the exposure has been judged. In the double film process a certain leeway is available, but when the film is to be reversed as in the case of the substandard cameras, there is no possibility of success without reasonably accurate exposure.

In exposure we have two quantities to consider. One is the intensity of the light and the other is the time with which the light acts upon the film. If we have a light of low intensity it must be allowed to act for a longer time and vice versa. However, as we have in many cases a fixed time in which the light must act, we change the aperture through which the light enters the camera. Thus with a light of high in-

tensity we use a small aperture and with a light of low intensity we must use a larger aperture. The size of the aperture is controlled by the use of the iris diaphragm.

In the most modern anastigmat lenses such as are used in motion picture work, we find that the gradations of the iris are numbered 3.5. 5.6, 8, 11, 16 and sometimes 22. These figures represent the relative aperture. The system of computation of these numerical values is known as the focal system. It might be thought that these numbers should correspond to the actual diameter of the aperture in millimeters or fractions of an inch, but such a valuation would be almost useless and would be very confusing, for the actual diameter of the aperture can be given a fixed value only when lenses of but one focal lengths are considered. Thus if we have an aperture of one-half inch in a two inch lens, that aperture will admit four times the active light which would be admitted by a four inch lens with a half-inch diameter aperture.

The necessity for a system which would indicate the relative apertures of all lenses, regardless of focal length was recognized long ago. Several systems have been used, but only the Uniform and Focal systems have stood the test of time and now the Focal system is universally recognized. Briefly, to find the focal value of the aperture the diameter of the aperture is divided into the focal length. Thus with a half inch aperture and focal length of two inches we have $2 \div 0.5$ equals 4. The relative aperture of that lens is 4 expressed as f 4.

It will be seen that the relative values of the f numbers vary as their squares. Thus to com-

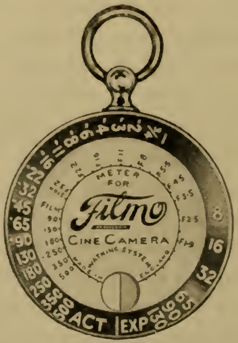
pare the speed to be used with f 4 and f 8, we find that the f8 requires not twice the exposure of f4, but four times the exposure. Thus 4 x 4 is sixteen while 8 x 8 is sixty-four. Sixteen is one-fourth of sixty-four and an aperture of f4 requires one-fourth the exposure of f8.

Roughly speaking, in brilliant sunshine, an adequate exposure will be secured upon normal negative film, at normal crank speed with an aperture of f11. This presupposes no nearby dark objects. This is but a rough guide as local conditions will alter this to a very great extent.

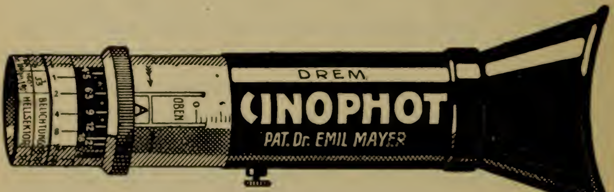
As proper exposure is of such importance, it is well to make use of some kind of exposure meter. There are several reliable meters upon the market, but as the readings have to be computed for the cinematographic camera it is better to use a meter made for this work. There are three high class meters on the market at present, designed for motion picture work. As it happens, these meters are of entirely different basic design. It may be said in passing that meters are roughly of three kinds. First, the tables for computing the exposure from average typical conditions. This is more properly an exposure calculator. Then there is the meter which measures the actinic power of the light falling from the sky and finally the meter which measures the intensity of the light reflected from the object. It will be seen that the last type is the more accurate, but in actual practice all of these meters are quite successful.

For motion picture work we have the Harvey Meter, the Rexo Meter and the McKay Cinemeter, all of which are calculators. These calculators, when set for existing conditions, show

the shutter opening necessary with each diaphragm setting. It is useful in that it immediately shows the permissible leeway in apertures with various shutter openings. Then we have



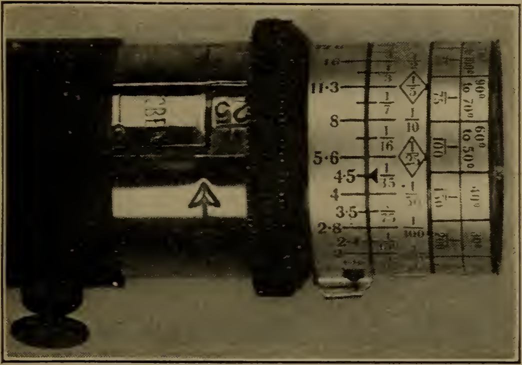
The Filmo exposure meter, an adaptation of the Watkin's Bee meter to substandard motion picture photography



The Mayer Cinophot, a scientific photometer which actually measures the actinic light reflected from the subject

the Watkins "Bee" Cine Meter. This meter has a small disc of sensitive paper which is exposed to the light. This paper darkens to the color of a standard tint upon the meter face. Seconds are counted while the paper is darkening and

when the tints match the time passed is used as the factor to compute the exposure by means of tables provided. Finally we have the Mayer Cinophot. This meter resembles a small pocket telescope. In use it is pointed at the object. Looking into it we see a number which is 1/25,



The scales of the Cinophot. Note that 1/25 is the fraction shown in the window adjacent to the arrowhead. This same fraction 1/25 enclosed in a diamond shaped border may be seen upon the center scale. In looking through the meter, extinction has been secured at 5.6 The fraction 1/25 on the center scale is now set opposite 5.6 on the upper scale and opposite the black diamond arrowhead on the central scale we read 4.5; the proper diagram setting for normal motion picture speed under the given light conditions.

1/5, 4 or 30. Outdoors we will usually use the 1/25. With the meter pointed at the object we turn a collar upon the instrument until this figure can barely be seen. Now looking at the scales we find that an index line upon this collar

which will point to some "f" number. Say this is 11. We now set the computing index, 1/25th opposite 11 and on the same scale, opposite a small arrow we read the proper iris aperture for normal speed motion photography. Other shutter speeds are also given so that the meter may be used with any shutter aperture or in time condensation work. It is a complete and reliable scientific instrument and, while slightly higher in price than other types, it will be found to be a valuable investment.

When we have determined the proper aperture for use under the existing conditions, we set the camera lens to this aperture. The camera is now ready for use.

If the camera is of the automatic drive type, all that is necessary is to support it in the hands or upon a tripod in such a manner that it will remain steady and press the release button.

If the camera is of the hand cranked type, a tripod is quite necessary. This tripod should have a top or head which will permit the camera to be swung through a horizontal arc (pam movement) and through a vertical arc (tilt movement). This will allow the camera to be swung so as to include any angle of view.

Before using the hand cranked camera, it will be necessary to master the art of cranking. The standard motion camera passes six inches or eight frames of film at each crank revolution. This means that the crank must be turned two times per second as normal cine speed is one foot or sixteen frames per second. In cranking, a steady, uniform motion must be maintained. If this is not done the film will be unevenly exposed and the subject will jump upon the screen. Crank-

ing must be practiced with the empty camera until this motion becomes habitual. The cameraman stands at the rear of the camera, his forearm almost parallel with the axis of the crank, while the actual motion is imparted to the crank by means of a wrist motion. In practice, a watch should be laid upon the camera and the cranking timed. Try to get so that you can crank between 116 and 124 revolutions per minute without watching the watch. When this can be done, you are ready to use the hand cranked camera.

However, only the professional and specialist uses the hand cranked camera these days. For amateur work, home work and similar lines of effort, the automatic camera is far better than the hand cranked instrument. In the substandard field especially, the automatic camera has become recognized as standard and for this work it is unsurpassed. Later, we shall consider some of the work which necessitates the hand crank. It may be said, though, that when it is possible to secure a camera which uses both crank and automatic drive, that such is the ideal camera.

In photographing a stationary subject, all that is necessary is to continue the exposure until the proper length of film has been used. Moving subjects, which are after all logical subjects for motion photography, fall into two classes, those which are under the control of the cameraman and those which are not. With subjects under control, it is easy to use the hand cranked camera, for the subject, being under direction, will not pass out of the angle of view and the camera may remain stationary. In this case the cameraman sets up, then watching the scene through his finder, he has the actors (subjects) go through the preliminary motion. If everything goes well

he will direct them to continue, usually by calling out "Action." Then, still watching through the finder, he starts the camera at the proper time, continuing until the scene has been recorded. This completes the "shot." However, stationary subjects and subjects under control will constitute not more than twenty per cent of the usual subject matter. Do not imagine that just because a subject is posing for a film that he is under control. Subjects under control are those who through practice have trained themselves to react instantly to the direction of the cameraman. Persons unused to motion picture work are almost as uncontrollable as those who are unconscious that they are being filmed.

In filming subjects not under control, the automatic camera is to be used. In this case, the cameraman, to the best of his ability, selects the proper position to show the action and to secure the best lighting, as has been explained. He prepares for the picture as has been directed and waits for action. When the subject comes into view the camera is placed in position. When the subjects comes to the proper distance the film is released and the camera starts. When this is done, assuming that the subject consists of a single person or group of persons, the camera is kept trained upon them, disregarding the background. This approximates natural eye action. We follow moving objects, almost unconscious of the background. If the camera is moved so that the subject maintains the same relative position, the center of the aperture for example, the film will give a perfect rendering of the scene which the eye saw. However, if the camera is not moved with the subject, if it is moved too fast

at first, then too slow, the subject will jerk about upon the screen in the most disconcerting manner.

Proper control of the automatic camera cannot be too strongly emphasized. It must be remembered that the actual motion of the camera will be shown upon the screen exaggerated by from fifty to two hundred times according to the size of the screen. An up and down motion, due to trembling hands, and amounting to one-fiftieth of an inch, would appear upon a nine foot screen as the motion of almost three inches! This of course must be avoided. Likewise, if the camera is swung from side to side to show a panorama, a large group of people or other stationary objects, the motion must be very slow and deliberate or the screen result will be painful to view.

When the scene has been filmed, it is well to "slate" it. Data in brief form or a distinguishing number is written upon a small slate and this is photographed upon three or four frames by a half turn of the crank. This serves as an aid to memory in later classification of the films.

Such is the usual procedure in motion photography. There are innumerable special methods, many of which can not be mentioned in a condensed work of this nature, but the more important will be discussed in other portions of the work under their proper headings.

Chapter Eight

TITLES

The infinite superiority of the motion picture over the spoken word has been explained and emphasized so often that it comes as a distinct shock to find that titles are more than a convenient convention. The title, or more properly speaking the subtitle or caption, is an absolute necessity in motion pictures. This is true for two reasons.

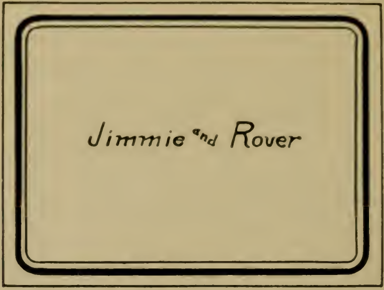
First, only the concrete can be photographed. Broadly speaking you can photograph only what you can see! You can photograph thought only by the transient expression it brings to the face. Abstract ideas cannot be photographed in any way whatever. In the second place, there are thousands who look at an object without seeing it. In other words you can show an object to the average person and that person will not realize the subtleties of the object until they are explained. Just so the motion picture must be explained for the benefit of those who do not understand what they see. Then of course it is better to explain a lapse of time by a short caption rather than to show endless thousands of feet of film filled with petty nothings. Such a monotonous procedure would ruin the finest film ever made. Brevity is the soul of the motion picture as well as of wit!

In the average film we have the introductory title, which tells us what it is all about, then ex-

planatory titles, spoken titles, titles indicating lapse of time, titles of emphasis and the usual main title, cast, and final title. The main title for professional work and for amateur as well should have a permanent design. Do not make a mistake about title design! A set of attractive titles will often put over an amateur film which would otherwise be poor; they will often sell a commercial film which would be turned down cold without them. As a race we are in love with our language and like to see it dressed up upon the screen. The permanent design will serve to identify your films, even as the bookplate does in your library. As the actual text matter has to be changed, this design should be of the cutout variety. That is, the decorative design forms a frame. The center is cut out and in this cutout space is placed the plain black title board with its plain white titling. For subtitles, the design should be artistic, but subdued. The decoration which is so heavy and complex that it draws attention from the words, is worse than none at all. But these things will be discussed in their proper places. We have seen that the titles serve a definite purpose, that they add to the attractiveness of the film (or should do so at any rate) and that they may well be decorated.

The first step in the titling of a film is the wording of the titles themselves. This should be the result of study and of careful consideration. Do not use florid language, do not use inverted order, do not use polysyllabic words. Write the title, unless it is a spoken or a "character" title, in good, plain English, as briefly as possible. The modern craze for slogans illus-

trates this. A short, snappy phrase which tells the story is acceptable to most people. Thus we will find that in the commercial film advertising



The motion picture subtitle presents problems which are seldom recognized by the amateur. There are certain considerations of wording and execution which cannot be ignored.

The title must first of all have unmistakable meaning. There should be no possibility of two meanings being derived from the title. It should be brief but not abrupt. In appearance it should be simple yet attractive. Intricate title cards are not necessary, and, in fact, the simple hand drawn card as shown here will often fulfill the desired purpose more satisfactorily than would the elaborate printed card.

The decoration can easily be limited to a simple two line border, and such decoration is always the best for the inexperienced title maker. The tendency is toward too much elaboration in heavy borders and motifs. Unless the title maker is absolutely sure of his artistic ability, the aim should be toward the utmost in simplicity. Simplicity in wording, simplicity in lettering and simplicity in decoration.

umbrellas, the title "It Sheds Water Like a Duck!" more serviceable than "The Watery Deluge from the Heavens has no more effect upon

it than it does upon the shining back of the Waterfowl!" Moreover brief captions save valuable footage for action! When you see a film replete with verbose titles the chances are that you are looking at a film in which the action could not be stretched to fill the footage. In other words, long-winded titles are pure "padding."

When the titles are written, their footage must be determined, for too often they will encroach sadly into the action footage, and must be pared down. No title should be less than five feet long, even if it consists of but a single word. Thus we have a five foot minimum.

Note: In this chapter and in others concerned with footage determination, the foot referred to is the standard screen second foot. When working with substandard cameras remember that the foot has no relation to the actual length of the film but means sixteen frames which will require one second for projection!

Longer titles give one second for each word, up to and including ten words and one-half second for each word after that. Thus a ten word title will require ten feet of film, a twenty word title will require fifteen feet and so forth. This enables us to predetermine the footage needed for titles. As the titles are made separately, they may be given excess footage and then cut to length during the process of edition.

When the titles are prepared, they are written out in order. This is the title continuity or "Cap Script." Such a list enables the actual title photography to proceed without delay. The camera work comes next.

Most titles are made in black and white, and with the fullest possible contrast. Many ama-

teurs use positive stock in the camera and develop in a hard developer. This gives beautiful black and white titles, but the process is fatal to any decorative work which includes any considerable range of halftones.

The title board is any kind of a flat surfaced easel which may be placed perpendicular to the lens axis and with its center lying in that axis. If the camera is placed in the usual position, the title board may be placed against the wall, or if the camera is turned so that the lens points downward, the title board may lie flat. This is the better position for it makes trick and animated titles easy to photograph. There are but two major requirements for the title board. It must be absolutely perpendicular to the lens axis and must be centered with the lens axis. If the board has one edge slightly closer to the camera than the other, the title border will be photographed narrower on one side than upon the other. If it tilts, the side nearer the camera will be the longer. If the board is not centered with respect to the lens, the title will be at one side of the frame, or decentered. To correct this we shift the camera and again distort the border.

If one size of title card is adhered to the distance from camera to title board may be fixed. This facilitates operations, but precludes some trick work. However for the usual amateur and commercial work, a stand which supports the camera above the title board at such distance that either 9 x 12 or 18 x 24 inch title cards may be used, is best. With such a stand the camera may be placed upon it and the cards upon the board and work started without delay at any time.

Titles should without exception be made by artificial light. The background is plain and there is no depth at any place so that the slightest variation in light will be instantly apparent. Likewise, any inequality of the lights upon one side or the other will show up badly. The lights must be balanced accurately, to provide a good, even illumination and fairly brilliant. One of the best light sources for title making is the mercury arc. One or two "M" tubes at each side of the title board will give plenty of light. It must be remembered that normal speed has no advantage except in time saving, so that when light is limited, the single crank may be used. In fact the writer uses the single crank almost altogether in title photography, using a small diaphragm for definition and a comfortably limited working light. When the title board is set up, look at the title in the direct focussing aperture if your camera has such an accessory. If not, stand back, and through half closed eyes study the board to see if you can detect any suggestion of non-uniformity in the lighting.

When the set-up has once been made, all titles may be made without any further setting of focussing. The exposure may be determined by the use of the Cinophot, or by exposing and developing test strips, exposed at varying crank speeds. In this work it is better to use an aperture of f8 or smaller, as this tends to give ultra-fine definition.

So much for the straight title. At times it is desired to make but one copy of a title. In this case, the title card is white, with black lettering. Positive stock is used in the camera and this film is cut into the completed film. In this case, the

celluloid or brilliant side of the title is placed with the emulsion or dull side of the action film. This is necessary because this title is a true negative and as such is reversed from side to side. This trick is of no value when many prints are to be made.

The usual title card is a special, mat or velvet surface black cardboard. The mat surface of this board is easily marred because any friction or pressure makes a bright mark which photographs remarkably well. The card surface must be protected at all times. Even while lettering the pencilled guides must not be carried beyond the limits of the letters and the card protected from the hand by a piece of spare paper.

In lettering the cards, the title is first drawn upon a sheet of ordinary paper. When it is corrected and found satisfactory it is transferred to the black title card by tracing. No carbon paper or other transfer medium is necessary as the pressure of the pencil will leave a mark upon the surface of the card beneath the paper. These outlines are then filled in with white ink. The letter outlines are drawn by the aid of draughting pens, straight-edges and irregular curves such as are used by all draughtsmen. This method makes possible the "occasional" letters which add so much to the attractiveness of a title.

For those who wish to make plain titles, with ordinary letters and plain borders, the gummed letters which can be purchased from any stationer are very satisfactory. I once saw a very neat set of titles made in this manner. The border was a simple two line affair, but in the lower left corner of each title was one of the little silhouettes which are used as printer's ornaments in

some of our leading magazines. By making use of such methods attractive titles may be made by persons who have no artistic ability.

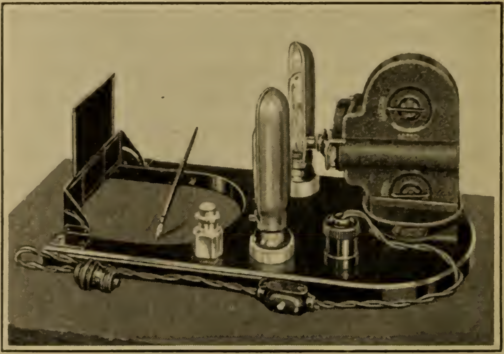
Then of course there is the special title board such as is distributed by Bell & Howell and by New York Institute of Photography. This is a board covered with dead black fabric. At intervals, slots are cut into the board and the fabric tucked into these slots. Letters of white celluloid are used on this board. These letters have projections which are placed in the slots mentioned, which holds the letter firmly in place, yet allows it to be removed or inserted with ease. This board may be used in making decorative titles by using the frame border as has been described.

In many cases, a somewhat more elaborate title is desired. When this is the case, an old wall paper sample book may be used to advantage. The tapestry designs and other soft, vague designs are best. These are used in place of the title card and as such designs usually have considerable brown, red, green, tan and so forth, the general tone will be quite dark, photographically speaking. This gives a pleasing relief from the monotony of black title grounds, yet the background remains subordinated to the white letters.

There is one title which I have seen which is very effective, and simple, yet which could be used too often. The background is a very subdued tapestry design. At the left of the actual letter area, a vertical band of scroll work runs entirely across the frame from top to bottom. This band is about one-eighth the width of the entire frame. The initial letter is hand drawn and forms an integral part of the scroll. The effect could be imitated by using a scroll design in pho-

tographically bold coloring and using a cut out initial.

The vogue for motifs seems to be permanent. The double-exposure motif will be explained in the chapter devoted to trick work. The hand drawn motif is merely a sketch appropriate to the scene which follows, and it is drawn in any desired portion of the frame, the lower left corner



The Bell & Howell Character Title Writer. This is really an amateur cartoon stand. While simple in design it is one of the most useful accessories made. While made for the Filmo alone it can be readily changed to adapt it to other cameras.

being a favored position. Motifs may be cut out and pasted on, but one of the easiest of these motif titles is the one in which the entire background forms the motif.

A still photograph is made and enlarged to about 10 x 12. This should be a "still" from the scene which follows the title, or it should be appropriate to the entire film. An incongruous mo-

tif will ruin the finest title! The enlargement is over-exposed and developed to a dull gray. The letters are then pasted upon this background. The dull, dark tone will form a suitable background, while enough detail will remain to identify the title.

Many other forms of decoration will occur to the individual operator, and there are few ways in which more individuality and quality can be added to the usual film, than by the use of a well conceived title decoration.

There are in addition many effective titles which can be produced by various tricks, but these will not be discussed here as they are basically trick work, and will be discussed in the chapter devoted to that work.

As a rule titles should be developed in a hard developer, but if care is used in exposing, the standard positive bath may be used to a very good advantage.

When the title is printed, it is rolled and set aside until the film is edited, at which time it is "cut" into its proper place as will be explained in the proper chapter.

Chapter Nine

LABORATORY WORK

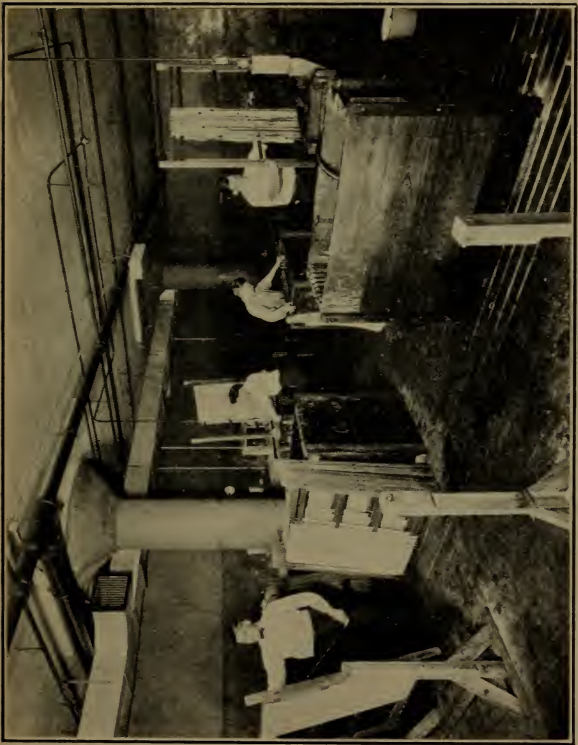
In this discussion of laboratory work no formulae will be given. These will be found grouped together in the Appendix. As many cinematographers have their own favorite formulae it is believed that the publication in this chapter would lead to confusion.

Laboratory work includes developing the negative, and printing and developing the positive. As positive stock may be obtained in both standard and substandard sizes in various colors, no discussion will be given of tinting and toning. Tinting and toning are difficult, expensive, dirty and troublesome processes and should be left to the commercial laboratory. To attempt them in the small laboratory leads into great expense due to ruined film.

Motion picture negative stock is fairly rapid, approximating 250 H & D. It is of fairly soft contrast. This gives us plenty of detail if properly exposed, and properly developed. As the emulsion is an ordinary photographic emulsion any developer may be used with it. However, due to the economy and trouble-free characteristics of the Metol-Hydroquinone group of developers, these are recommended. The Eastman 16 formula is an old favorite and hard to beat. It may be added that while number sixteen is used for both negative and positive, the same solution should not be used for both purposes.

Only negatives should be developed in the negative bath and only positives in the positive bath.

For developing motion picture film, some kind



Developing Room in the Rothacker Laboratories.
(Courtesy Rothacker Film Co.)

of tank must be used. In the large laboratories, the large wooden tanks taking a wooden rack of 200 foot capacity are used. These tanks are large, heavy and necessitate a huge amount of solution.

For the usual commercial studio and for amateur use, the Stinemann tanks are ideal. These tanks are round in form, and the rack is a spiral of metal in which the film is wound. When full the turns of film are separated by approximately one-fourth inch. The film is wound with the celluloid

The Stinemann developing system is also adapted to the development of aerial mapping camera films. As shown, the only change is in the depth of the racks and trays. The same system is used for all gauges of motion picture film, the racks and tanks changing only in depth.

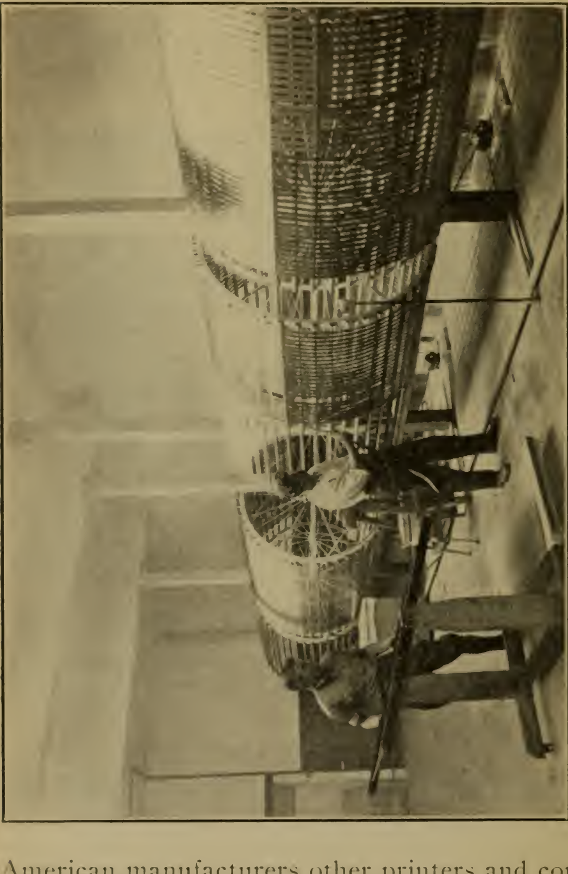
side next to the metal supporting ribbon, giving free access to the entire emulsion surface. This rack, when filled, is lowered into the tank of developer, and due to the compact design, one hundred feet of film may be developed in two gallons of developer. These tanks are used by travelers,

explorers and small laboratories all over the world and have given entire satisfaction. They are not entirely suitable for large plants due to the increased time necessary for loading the rack properly, but this is their only drawback, and one which is of no moment when less than one thousand feet per day are developed. The Zeiss-Ikon firm also makes a tank of similar design. The latter firm makes a small capacity wheel tank for developing up to fifteen feet of film, but it is so large in comparison with its capacity that it is hardly practical for the commercial laboratory. It is purely an amateur apparatus. The Stinemann outfits, including tanks and printer, are now available for use with the 16 millimeter film, enabling the amateur to do his own work.

The printing machine is one of the sorest points for the laboratory man. A really high-class professional printing machine costs well up into the hundreds, and so is not available except for the larger plants. However, as the printing machine is really nothing but a camera movement with a light source, there are several small printers which are ideal for the small laboratory and which produce work which is satisfactory in every respect except that of speed and quantity of production, again this is of no importance when less than one thousand feet per day are to be printed.

There are several cameras which are arranged to be used as printers. Of these the Ernemann and Zeiss-Ikon Kinamo are outstanding examples. The Kinamo (universal model) has a special magazine for this work and also a small attachable printing light which is placed in the lens mount. Such combination instruments are

practical in every way and are quite common in European cameras. There are indications that there will shortly be placed upon the market by



Drying drums in the Ince Studios. (Courtesy Thos. H. Ince Studios)

American manufacturers other printers and combination camera-printers.

When the film is developed it must be dried

and this brings us to the drying drum. Film should not be hung up upon a line to dry as the lower portions or loops will dry more slowly than the higher portions resulting in uneven density. A drum or rack made for this purpose is indispensable. The Stinemann equipment includes a compact folding drying rack of very good design, and with it being available there is small excuse for the use of cumbersome home-made racks. In case the rack is to be built at home, it can be easily done. Two wheels or discs of wood are secured and firmly mounted upon an iron rod. This rod in turn is mounted in bearings so that it will turn freely, a pulley is attached to the rod and thin wooden strips are nailed to the end discs, each strip extending from one disc to the other. When completed the drum appears as a skeleton barrel. The strips should be thin enough to bend easily, but not so thin as to be fragile. The actual dimensions will depend upon the size of the drum. The thin strips are used so that the film will have room for contraction as it dries. If a rigid drum were to be used, the film would tear loose when drying.

The dimensions of the drum may be calculated when the length of film is known which is to be dried. Thus if we want to dry one hundred feet of standard film, we must have a surface equal to a band two inches wide and one hundred feet or 1200 inches long. We decide to use three foot end discs. This will give us a circumference of roughly nine feet or one hundred and eight inches. Now we have 9 x 12 equals 108. If we have twelve circumferences we will have a drum capacity of about one hundred eight to one hundred ten feet. We need a minimum of two inches

per circumference and three inches for the spiral overlap. $12 \times 2 + 3 = 27$ inches, the length of the drum. On the other hand, a drum for drying 16 m/m film in 100 foot lengths may be two feet in diameter by 13 inches long as the film may be wound in ¾ inch widths.

In addition to the tanks, racks, and drying drum or frame, the usual small accessories will be required, consisting of safelight, scales, graduates, hydrometer, mixing jars and so forth. A complete supply of chemicals will also be needed including metol, hydroquinone, sodium sulphite, sodium carbonate, powdered alum, acetic acid, citric acid, alcohol, potassium bromide, potassium permanganate and so forth as indicated in the various formulae.

For the small laboratory, not especially equipped for the work the reversal process should not be considered, as this is a highly specialized kind of finishing work, and has not yet been placed upon a satisfactory basis except in the huge commercial laboratories. However, this is no disadvantage, for rarely would the commercial cinematographer wish to reverse his films. A brief comparison of the two processes will serve to show the reason for this.

The film prepared for reversal is a compromise emulsion, having some of the good qualities of both the negative and positive emulsions. This film is sensitive (fast) enough for use in the camera, yet slow enough to provide a satisfactory amount of contrast for an acceptable print. The final result is somewhat more dependable upon the initial exposure than in the case of the two film process, as the same amount of control cannot be exercised, and finally a reversed film

for home use must be made upon the acetate film base, which has not the long life of the nitrate film, and in time becomes brittle and hard. When this happens satisfactory duplication cannot be done, and the film is lost. The nitrate negative film as can be used in any camera is a flexible, long lived film, and when a positive becomes hard or is otherwise damaged, another print is easily made.

The reversal process is a specialized process for a special field, and in that field it has enjoyed unsurpassed success. It has provided the simple, inexpensive film which made possible the popular interest in amateur cinematography which exists today. It has given a fine grained positive, which has excellent screen quality when projected to a small size, and at one time was the only practical process for amateur work. The reversal process will continue in favor until the large laboratories themselves discard it for another process. Whether this will happen in the very near future, or never is something that only time will tell.

For the home developer, for the commercial cinematographer with his own laboratory, the two film process is the only one to be considered. For personal development it is cheaper than the reversal process, it provides a permanent master negative for making any number of positives, and may be developed in tanks such as the Stinemann, at any time and in any place without fear of failure. And finally there is the great advantage of contrast.

The reversed film, in order to meet the many requirements of a perfect amateur film, had to have some qualities sacrificed, just as we sacrifice

depth in a lens to secure an extreme aperture. We do not condemn the lens for the lack of depth, nor need we condemn the reversed film for lacking some qualities which cannot be incorporated without eliminating other even more valuable qualities.

Films shown in theatres must be above a certain minimum quality. In fact they must be very good if used at all. On the screen we see soft focus shots and needle sharp definition, we see comedy distortion, and the use of selective filters. We see tints and tones. We see every possible photographic effect with one exception. We do not see soft contrast, except in the case of fog and storm scenes, and shots of similar character. Neither do we see "soot and whitewash." Why? The negative is made upon purely negative stock which is soft in contrast and provides us with a wealth of detail. This is printed upon a short scale positive stock which takes up these details, and builds up, rounds out each one with sparkling brilliancy, and by the combination of the two we get a snap and roundness which is at times pseudo-stereoscopic.

For purposes of comparison, and for your own satisfaction, secure a roll of reversal film and one of negative stock for the same camera, and expose both under identical conditions. Have the reversal film finished in a professional laboratory, and develop and print the negative with your own Stinemann—then test the positive by projecting them side by side. You may prefer one, another may prefer the other, but make the test for your own satisfaction.

Every true amateur and every worthwhile commercial cinematographer will make a practice of

developing his own films. Reversal is somewhat tricky and if the film is spoiled it is gone! Ordinary development is as simple as any chemical reaction can be, and there is rarely any excuse for spoiling a film during development. If a print is over-exposed or otherwise spoiled, only the film is lost for the master negative remains. Home development with the two film process is as simple and easy as could be imagined.

Let us suppose that the film is to be finished for the two film process. The first step is to make up the baths. In preparing a developing bath, it is of advantage to dissolve each chemical in a separate portion of distilled water, and to then mix these solutions. The exception is that the hydroquinone should be dissolved in the sodium sulphite solution, as it dissolves much more readily in this than in pure water. By following this plan, the bath will remain clear for a longer period than is usually the case and the precipitate of "sludge" will be reduced to a minimum.

For use with the large tanks, a ten or fifteen gallon stoneware jar is quite handy for the final mixing, while one or two gallon glass jars are used for making the individual solutions. When the compact tanks are used, large graduates are used for the individual solutions while the mixing may be done in the tank itself.

The formulae as given by various manufacturers may be in avoirdupois or apothecaries weight. When the system used is not given, avoirdupois is usually understood. However, it is best, by far, to accustom oneself to the use of the metric system. This is universal, it is unvarying, and it is the only scientific method of measuring.

In making solutions by liquid measure, it will

be seen that the liquid rises at the sides of the graduate leaving a perceptible hollow in the center. In making measurements, the liquid level at the sides of the graduate is disregarded. The graduate is held at eye level and solution added until the bottom curve of the hollow at the top of the liquid coincides with the capacity line engraved upon the graduate.

The use of distilled water is recommended but if tap water is used, it should be drawn at least two hours before use and allowed to set until it has assumed the room temperature. The ideal developing temperature is from 65 to 70 degrees Fahrenheit. However, a change of temperature during development is far more serious than a constant high temperature. If the developing and fixing baths are of different temperature, reticulation will occur fully ten degrees below the point where it occurs if the baths are of uniform temperature. If the fixing bath has the proper hardener added, there will be slight danger of reticulation, frilling or blistering at any temperature below 85.

All baths should be made up and placed in the tanks before starting work. The film is then wound upon the rack, secured in place and the rack submerged in the developing bath. The rack is gently raised and lowered four or five times to remove air bubbles. It is also lifted once or twice at intervals of a minute or so during development. With all factors as they should be, that is, exposure, temperature, developer strength and so forth, the negative will develop in about ten minutes. Some technicians like a five minute developer and some use a fifteen or even twenty minute developer. It must be remembered that

with the same exposure, a quick developer will give contrast at the expense of detail while the slow developers will give detail at the expense of contrast. By using a medium developer we can get both contrast and detail.

Developers may be controlled by varying the temperature of the bath and the strength of the solution. The temperature cannot be varied within very wide limits, for at a high temperature we get a flat, dull negative, with great danger of frilling and other faults of the gelatin emulsion. With a low temperature the hydroquinone refuses to act and we get a lack of brilliancy. The high temperature flatness is due to chemical fog or "veil" induced by the increased chemical action at high temperatures while the flatness of the low temperature bath is due to the fact that we use a soft developer, as the hydroquinone will hardly act at all at temperatures below 55 degrees. The only logical developer control, then, is the control of the strength of solution. In doing this we find that the strong, rapid developers give us harsh contrast while the weak, slow developers give flat detail. Hence the medium strength is best for normal use.

Any form of time and temperature development may be used, but it will be found to be more satisfactory all around to experiment with test strips and find the developer strength best suited for the individual work in hand. When this is once done, it will be easy to formulate a time and temperature scale for oneself, using the British Journal or American Photographic tables as a basis.

A fully developed negative is one in which the darkest portions appear quite opaque when

viewed in the darkroom by transmitted ruby light, before fixation! The image will usually be clearly visible upon the back of the film, but this is no criterion. To judge a negative by inspection, only transmitted light should be used! When the negative is fixed, washed and dried, the densest portions of the silver deposit should be so transparent that a newspaper can be read through them. A black, clogged deposit will give a chalky high-light, which is to be avoided by all means. In the darkroom, due to the dim light and the deposit of unreduced silver salts, such a translucent deposit will appear quite opaque, in the developed but unfixed negative.

When the negative is developed it is rinsed in a five per cent solution of acetic acid. The developer is quite alkaline in reaction due to the carbonate. If the negative were to be placed directly into the fixer from the developer, the acid of the fixer would soon be neutralized and the troubles of softened emulsion would crop up. Not only this, but oxidation stains are far more frequent when the acetic acid bath is not used. The saving in fixing bath will more than pay for the small amount of acid used.

After the acid bath, a rinse in plain water will not hurt the film at all. It is then placed in the acid fixing bath. By all means, in motion picture work, the acid bath should be used as routine. The hardening action will save many feet of film which would be lost otherwise.

If the film is rinsed in acid between developer and fixer as has been advised, the white lights may be turned on in the darkroom after the film has been immersed in the fixing bath for two minutes. The light should not exceed twenty-

five watts and should be at least ten feet distant from the tank.

With fresh bath, the creamy color due to unreduced silver salts will have disappeared, but this is no indication that the film is fully fixed. With a fresh twenty to twenty-five per cent solution of hypo, the fixing should continue for at least ten minutes and fifteen is better. With a fresh strong fixing bath, the image will be slowly reduced in intensity, and if allowed to act for several hours at a rather high temperature, hypo toning will start turning the image from black to sepia. Therefore, the film should never be left in the fixing bath for more than one-half hour. If the creamy color does not disappear within ten or twelve minutes discard the fixing bath and make up fresh.

When the film is fixed it must be washed. This is a far more important matter than is usually considered. Thorough washing is vital to a permanent film. The film should be washed until the water from the washing tank will pass the following test. In one ounce of the wash water place one drop of saturated solution of potassium permanganate. If the color remains decidedly pink or rose-color for five minutes the film is thoroughly washed. If not, there is still hypo in the water which gradually turns the color to straw yellow or brown. In case of high temperature where quick washing is necessary, a quantity of potassium permanganate solution is mixed. In one quart of water, dissolve one ounce of potassium permanganate crystals. Fill the tank with water and add this strong permanganate solution until the color is a deep rose. Do not allow the water to turn a decided purple for that indi-

cates that the solution is too strong. Rinse the film and place it in this solution. The pink color will turn to muddy brown. Rinse the film and place in fresh, weak permanganate. With each change of solution the time required for the color change will increase. The solution will be turned to straw yellow instead of brown after a time. Continue alternating water and weak permanganate until the watery permanganate remains pink for two minutes after the film is immersed in it. With each change make the permanganate slightly weaker until at the last it is but of a slight pinkish tinge. When this color persists for two minutes, practically all hypo has been removed. The film is now rinsed in five changes of water and dried. With this method it is quite possible to thoroughly wash the film in five minutes.

When the film has been washed, it is placed upon the drying rack. The film is wound directly from the developing rack to the drying rack or drum. When the film is all upon the dry rack, the rack is slowly rotated until the film is dry. This gives a uniform density throughout the film. The rack or drum may be turned by connecting a suitable electric motor to it. The pulleys used should be of such size that the rack turns not less than thirty nor more than one hundred and fifty times per minute. One revolution per second is a good speed for small racks and drums.

When the film is dry, it should be polished. It is inevitable that some water marks will be left upon the celluloid side of the film. A pad of absorbent cotton or even better, of chamois skin, is thoroughly wet with alcohol. It should not drip, but should be quite damp. This is passed beneath

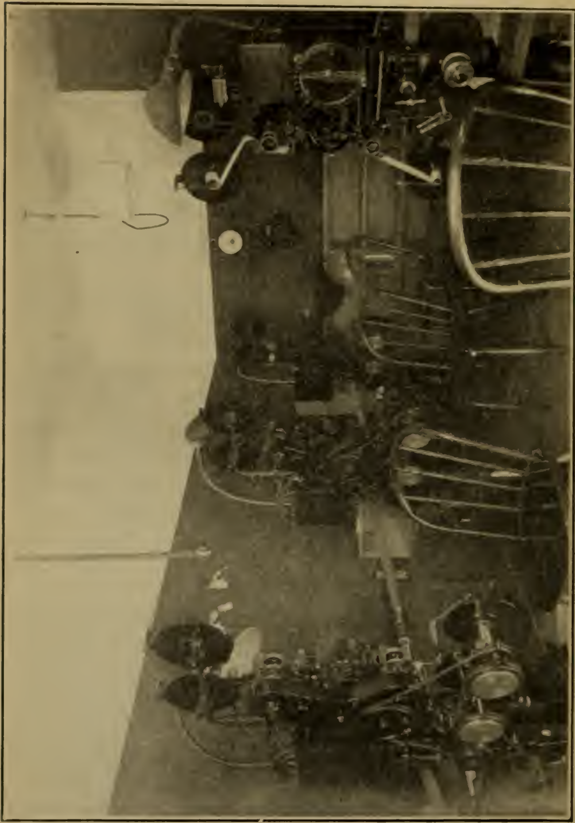
the film and held against the back of the film by the fingers. The drum is now rotated by hand and the pad rubbed upon the back of the film. This removes all such marks. The film is now ready to be transferred to the winding reel. The film may be wound directly upon this reel by having the latter mounted upon a movable stand, or the film may be gathered loosely in a basket and transferred to the cutting room.

If preferred the unpolished film may be taken to the cutting room where it is wound upon a reel. Then using the ordinary rewind it is passed from one reel to another and polished as it is rewound.

When the film is dry it should, whenever possible, be allowed to stand for a week or so to "age." That is, to shrink. This is important when a continuous printer is used. With a step printer, such as a camera combination, green film may be printed with considerable satisfaction, as the error due to expansion is compensated in each frame. However, if our hundred foot length of film has expanded three inches in length, we find that at the end of printing with some continuous printers we have over-run four frames, so that in projection we see the frame line cross the screen four times during the one hundred seconds projection time. With a step printer this error is reduced to one four-hundredth of a frame or about a half thousandth of an inch, and as the error is constant it may be disregarded.

When the film is ready for printing, the negative and positive stock rolls are loaded in such a manner that the celluloid side of the negative will be next to the light aperture of the printer. The positive stock is loaded so that its emulsion

will be in contact with the negative emulsion. The printer is now ready for use. In starting it is best to print a foot or two and then develop



Bell & Howell printers used in Ince Studios. (Courtesy Thos. H. Ince Studios)

this test strip. This will indicate the proper speed for the printing. After a short time the laboratory technician will be able to judge the

proper printing speed by looking at the negative by transmitted light. The printing is carried on in a dark room of course, while the printing light is so shielded that no light escapes except through the printing aperture. The printed film is developed and fixed just as the negative, ex-

Illustrating the method of loading the Stinemann developing rack. The film is wound into the spiral channel, the convolutions of film being supported by the metal band.

cept that the developer used is a separate bath, and the film printed so that it develops in approximately half the time required for negative development.

There is probably no developing and printing outfit available for general amateur use which is better than that manufactured by R. P. Stine-

mann, of Los Angeles, which has been mentioned earlier in this chapter.

The film rack is a thin band of metal wound spirally and firmly soldered to cross arms. This rack or reel as it should be called is provided with a central hole which fits ordinary rewind. This reel is placed upon a rewind and the film attached at the center of the reel and to the metal bands and then the reel is rotated by the left hand while the right hand guides the film into place upon the rack. When the film has been completely wound upon this rack the second end is fastened to the metal band with a clip.

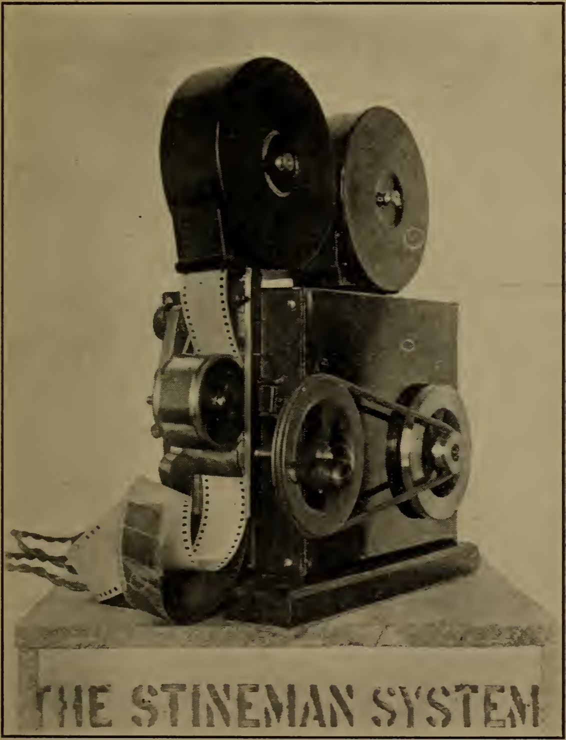
When the film is in place the rack is grasped by a handle at the center and carried to the tank. The tank is of metal and a circular shape about three inches deep. The outfit consists of one rack, three tanks and a screen which may be had in different sizes.

One great advantage of this system is the fact that a very small amount of developer is used. The film developed and rinsed and then placed in the fixing tank. After fixing, it is washed and when thoroughly washed the rack is removed from the tank. The fastenings are removed from the ends of the film and the whole reversed upon a wire screen which is provided.

From this screen the film is wound upon the drying rack. When the film is ready for printing it is placed in the rear retort of the printer. The positive stock is placed in the front retort. The printer is then threaded and the operation carried on by turning the crank at the side of the machine. These outfits may be obtained for both 35 and 16 mm. film.

The standard size equipment has been used for

years by travelers, explorers and other professional cinematographers and has in every case given the fullest satisfaction. The equipment cannot be too highly recommended for those who



The Stinemann continuous printer. This printer has a curved printing surface which compensates for stretched film allowing a print of the finest quality to be made by the continuous method. The light aperture is controlled by a lever on the front of the case while the machine may be operated by hand or by electric motor. This machine is made for both 35 mm. standard and for 16 mm. substandard film.

do not wish to establish a complete commercial laboratory.

In a manual of this size it is impossible to treat all of the available printers. However, they are roughly divided into two classes, the continuous and the step printers. Continuous printers carry the two films past a slit aperture at a uniform speed. With green negative this printer is apt to crawl when printing long lengths of film. The step printer works just like a camera. That is the film is advanced one frame at a time by an intermittent movement, and the exposure made only upon stationary film. All camera-printer combinations may be regarded as step printers. For usual commercial and amateur work there is but little choice.

When the positive film is dry, polished and wound it is ready for the first projection which precedes edition.

Chapter Ten

EDITING THE FILM

There are few steps in the preparation of the film which are more important than edition, yet there is no step which is more misunderstood by the average commercial and amateur cinematographer than this.

Poor editing will invariably ruin the finest film, while good editing can often turn a mediocre film into one of considerable quality.

Edition consists of removing all superfluous footage, assembling the film in proper order and insertion of titles. Simple, isn't it? But it is not as simple as it appears. Few laymen understand that there is just one proper point at which to cut a scene. Six frames before this point is too soon, six frames afterward is too late. In the one case, the action is interrupted and the sequence becomes jerky, in the other case action drags and the film becomes monotonous. It is a fact that we subconsciously note things which we cannot consciously perceive with our ordinary senses of perception.

In the first place, we will suppose that the entire negative has been printed and that we have the print in the cutting room. First of all we go over the positive and cut it at the end of each scene. We now have a number of film strips, each from ten to thirty feet long, and each consisting of just one scene.

Now, it is common practice, and sensible prac-

tice to make all shots on one location, or with one group of actors, at one time. This is done regardless of the position of that particular shot in the completed film. For example, if we are filming a child's day at school, we will make the shots showing the child leaving home and returning at the same time. Then when we go to the school we do not have to come back to the home again. Such methods conserve time, energy and money. Naturally, then, when the scenes are cut apart, they are arranged in the order in which they are to appear in the completed film. During this operation, the value of the "slate" will be seen. Each scene will have its identification at one end, and this identifying portion remains upon that scene until the acutal edition occurs.

With all of this handling, it is evident that some equipment will be necessary. Film boxes are easily made from wooden strips and wallboard. A box is made about two feet square. Above this box a crossbar is supported by uprights which rise from the center of opposite sides of the box. In its completed form it slightly resembles an over-grown flower basket. Upon the cross bar, hooks are placed. The small brass hooks used for hanging pictures are quite good. A size should be used which will pass readily through a film perforation.

Now, with the scenes cut apart, we have the beginning end of each scene upon a hook, allowing the free end of the strip to fall into the box. Thus any desired scene is instantly available.

Using a second box, we cut apart all titles which are to be used in that particular film. Upon one side of the crossbar we hang all main

and sub-titles, and upon the other side all spoken titles. The reason for this will be seen shortly.

For edition we use a table of convenient working height. Directly in front of the operator, a piece of plate glass about five by ten inches is

The equipment used in the cutting room is simple. Here we have film cement, splicer, steel guide, razor blade and scissors.

sunken into the table top until its top is flush with the table top. Beneath this glass is a box which contains a ground-glass diffusing screen and an electric light. At each side of the glass, and at the edge of the table, are the double rewinds. Each rewind is geared so that film may be run in either direction. At the rear of the glass slab, a film splicer is secured permanently to the table, and beside it are placed the film knife, the water jar and cement bottle.

We now place the main title upon the left rewind. Be careful to have all scenes which follow start at the left. There is no excuse for a reversed scene in edition. When the main title is wound, attach the "cast" title to it by means of a paper clip, then attach the credit titles if any and finally the introductory title. Now we are ready for the opening scene. This is attached to the introductory title and wound upon the reel. At this point you will realize the immense advantage of a continuity. If you have a con-

A pair of rewinds with film splicer, cement bottle and other cutting equipment. The rewinds are essential in edition.

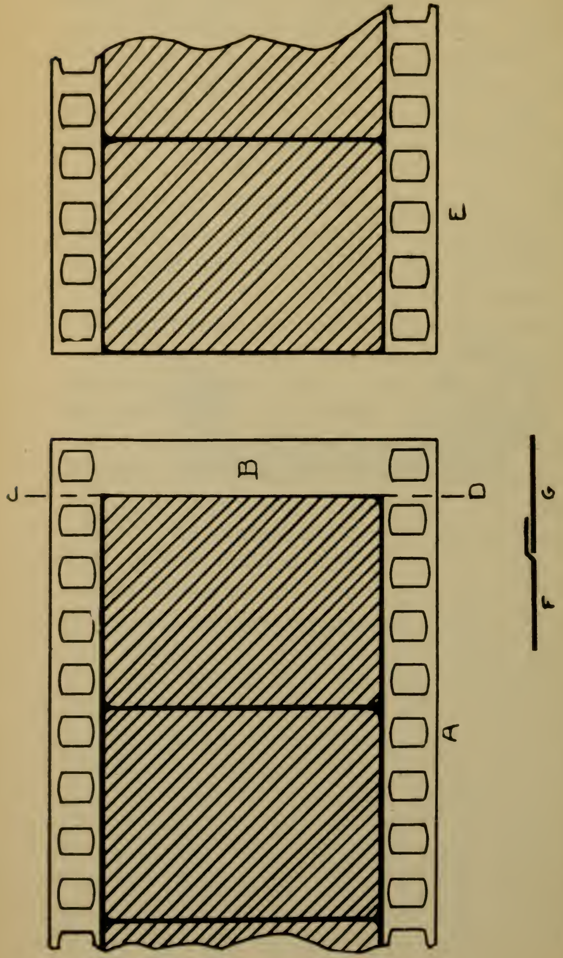
tinuity, it is now used for reference and the scenes and titles assembled in proper order, except that no spoken titles are inserted at this time. When this operation is complete, the whole film will be strung out in proper sequence, the separate pieces of film being held together by paper clips. This film is now rewound, and the first joining is started. The main title is cut to length as are the other titles of the introductory series. They are cemented together in the proper order. Let us consider the cementing or joining.

The first thing to note is that the liquid is not

a cement. It has no characteristics in common with paste, glue or mucilage. It will not cause any material except celluloid to adhere. It is really a celluloid solvent. As it has no effect upon other substances we may expect that it will not affect gelatin. Therefore the emulsion must be removed from the area which is to be cemented.

One film is cut exactly upon the frame line, the piece which is to be joined to it is cut across, midway between two frame lines and the emulsion is scraped from this short stub of film, up to the adjacent frame line. We now have the film so prepared that when we lay one frame line over the other, we have a tab of emulsion free celluloid extending under the adjoining film end for a space of ¼ frame. Now if we apply a liberal amount of cement to this tab and immediately place the free end of the other piece of film upon this tab and press lightly but firmly, we will make a joint. The cement softens the celluloid of both pieces, and the pressure makes a true weld. When the cement solvent has evaporated, the joint, if well made, is virtually one piece of celluloid, and the film should tear in a new place before the joint gives way. The one great point in joining, aside from making a perfect "weld," is to be sure that the overlapped perforations **exactly** coincide. If they do not, the film may be ruined by the projector. The joint should ride through the projector so smoothly that no effect can be noticed. If you can project a full reel without being conscious of a joint (unless you look at the screen, of course) you have made a perfectly joined reel.

The use of a splicer is always advisable. They



Film Patching. The frame line CD on piece A is left intact. The emulsion is removed from the short tab B. The end of piece E is placed upon tab B immediately after covering B with film cement. Perforations are exactly superimposed and the two films pressed into contact, making the joint as shown at FG.

are inexpensive, they make a neater and quicker patch than is possible by hand, and they make a firmer weld.

During this first joining, no attempt is made at edition. The rough ends, the "slate" frames and everything except actual action and titles are removed from the film. When it is joined, it is ready for the first projection. The film should actually be projected at least three times at this stage of cutting. This will familiarize you with the "story" of the film. Only at the third or fourth projection will you start to think, "Now that bit can come out." "That scene wants to be clipped by five feet." "There is a shot where the opening drags, three feet off the beginning," and so forth. Some editors take notes, others merely familiarize themselves with the film.

The film is rewound and again taken to the cutting table. The titles are shortened if necessary, then each scene is trimmed according to the impressions gained during the first series of projection. When a bit of film is removed, a patch is made immediately, so that when the film is completely re-cut it is again ready for projection. This time, the removal of the serious faults will bring to light minor faults. These are eliminated in the same manner. The film is cut a second time. During the third run, the faces are noted and the places for inserting spoken titles determined. The film this time is trimmed according to the last projection. Then the spoken titles are cut in. The frame is sought where the actor's mouth is opened to start the speech. This is traced through to the end of the speech, and the spoken title inserted about twenty or twenty-five frames before the end of

the speech, but if it is too long, some film may be removed from the midst of the speech action. Thus upon the screen the actor will speak just long enough for us to fully realize that he is saying something of importance, say from three to ten seconds, according to the drama demanded. Then the title flashes, we learn what he is saying, and for a second we see the closing motion of the speech which leads us smoothly into the following action. There is quite an art in cutting spoken titles into just the right place, but once acquired, it will improve films immensely.

During the fourth projection, full attention is given to these spoken titles to see that the effect is just right. Probably, two or three titles will have to be shifted for a space of a half dozen frames or so. Then in a second run the film is viewed as a whole. This allows you to determine the final touches, which are given in the cutting room, and the fifth projection or rather the fifth series of projections, should see edition complete. This gives us the positive master. We now cut the negative apart, just as we did this positive, and using the positive as a guide we cut the negative to correspond. This procedure is followed because it often happens that in the edition of the positive, single frames are cut in and cut out so often that there may be five or six patches in a single foot of film. This would ruin a negative, so it is not touched until the positive is satisfactorily edited. Negative cutting is mechanical as the positive master is followed without deviation. The negative is never projected. To project the negative is to risk scratching it in the projector mechanism.

When the negative is cut and joined, it is ready for use in printing exhibition positives.

There are two aphorisms which may well be remembered:

A film worth taking is worth editing.

A well edited film is an enjoyable film.

When the film is edited it is ready for the projection before an audience.

Chapter Eleven

PROJECTION

A book could be written concerning projection alone. In fact some books have been published which deal with this phase of the work alone, but a few judicious hints should in conjunction with the manufacturers' instructions, make any cinematographer a capable projectionist.

Projectors are legion in design. We have the immense theatre projectors which weigh hundreds of pounds and we have projectors which can be carried in one hand—and we have every conceivable type in between. All of them give satisfactory results if they are carefully designed for serious work. The toy projectors which are made on the lines of the old magic lantern are useless and time spent upon them is wasted.

We may group the projectors as: Professional, as used in large theatres; semi-professional as used in schools, clubs and semi-public auditoriums; home projectors, which are compact, light and designed for home use only; portable, which are usually of the suitcase type, and the semi-portable which are of a design which is a compromise between the semi-professional and the portable. For the commercial cinematographer, there are two ideal projectors. The DeVry, which is the highest class suitcase projector yet designed, and the Holmes, which is a semi-portable. For the amateur, the DeVry is fine for standard work, while some of the imported skeleton pro-

jectors are entirely satisfactory. For the amateur using the substandard film sizes, there are the Bell & Howell, which is a wonderful instrument, the two models of Eastman Kodascopes, the Victor, The Oxford, the Salex, all in the 16 millimeter gauge, the Pathe Rural in the 17.5 millimeter and the Pathex in the 9.5 size. Every one of these projectors will give entire satisfaction if used intelligently and not abused.

The projector mechanism is quite similar to the camera mechanism. The intermittent of the projector is usually a Geneva star cam, as this is a sturdy movement which will give long service and which is quite satisfactory for this purpose. The shutter usually has an extra or "flicker" blade to overcome the flickering appearance of the picture upon the screen. The camera body is replaced by a lamp house, while reels are provided for long film lengths.

The basic parts of the projector are: Upper reel or magazine, drive sprockets, intermittent movement, lower reel or magazine, lamp house, illuminant, aperture, shutter, lens and stand.

In professional theatrical projectors the films are contained in magazines. In some types of suitcase projectors and some types of semi-portable projectors this is also true, while the home projector usually has open reels. Magazines are used to minimize the danger from fire, and the home projectors do not need this precaution as they have low power lamps and are licensed for use with slow burning film only.

The projector uses three general types of film drive sprocket. Some use the single sprocket just as in the camera, the film being driven by both upper and lower faces of the sprocket. Some pro-

jectors which use side-by-side reels use two sprockets fastened to a single shaft, while others two separate sprockets driven by gears or chains. This drive is that part of the mechanism which provides the uniform film motion only.

The intermittent motion is usually provided by a star cam or "Geneva movement," but some projectors use the claw motion. In amateur projectors, the Victor is a type of claw driven projector.

A lamp house must be provided. As the illuminant is usually mazda bulb, the lamp house may be made small and compact. It carries a reflector behind the bulb and a condenser in front of the bulb but behind the film.

The best illuminant for amateur and commercial projection is the incandescent bulb. Other illuminants are arc, lime-light, acetylene gas, and incandescent gas burner. The arc may be used for long throws, but the most serviceable, satisfactory and simplest form of illuminant is the incandescent bulb.

The aperture plate and pressure plate forming the gate, is merely a guide for the film. It is of polished brass or steel, and must be kept in perfect condition. Its only requirements is that it keep the film perfectly flat in the aperture.

The shutter of the projector is the usual rotary, fan-bladed shutter. It is provided with an extra blade known as the flicker blade. This extra blade eliminates the painful flickering of the image seen when an ordinary camera shutter is used for projection. The shutter blades may be solid as is usually the case, or the blades may be perforated as in the case of a certain patent shutter. The perforation allows the screen to retain a certain

amount of illumination during film travel, which makes the alternating light and dark screen less painful to view.

The lens is any good projection lens. The most apparent difference between the projection lens and the taking lens is that the projection lens has no iris. In fact, however, a very simple, inexpensive lens will often give quite satisfactory projection when a similar lens would be absolutely worthless in the camera.

The projector may or may not have a stand. If not, it is used by placing it upon a table or other suitable support.

Projectors of all types may be secured with either hand or motor drive. The hand cranked type, however, is considered obsolete, and rightly so. There is no reason why it should ever be used, except in cases where there is no available electric current. With current at hand, the projector should in every case be motor driven.

Before projecting, the projector should be run idle for a short time, five or ten seconds. If any trouble has developed it will make itself konwn. Then the film is placed upon the supply reel, threaded according to the manufacturer's instructions for that particular projector, and led to the take-up reel. In threading be sure that the teeth of each sprocket properly engage the film perforations. To neglect this point is to endanger the film.

The projector is now turned on for an instant. If the film feeds properly, the projector is turned off and the room darkened. The projector is then started again. The image as it appears upon the screen must now be focussed. This is done by varying the distance between the lens and film,

and is accomplished, usually, by means of a spiral lens mount.

When the image is focussed upon the screen, the frame line may be visible, and a part of the picture cut off. This is remedied by moving the framing lever until the entire picture appears upon the screen, with no frame line visible. With substandard projectors, this error will be slight, as there are but one pair of perforations per frame, but with standard film, the frame line may appear midway in the aperture. In this case the film should be rethreaded, so that the film frame approximately fills the aperture and the framing lever used only to correct any slight remaining error.

When this is done the film is allowed to run undisturbed as long as no trouble arises.

There are several things which may go wrong in projection. Some of the more common troubles are:

Film Stops—Look to see that both loops are correct. A lost loop may stop the projector. Connection between motor and intermittent broken. This is a rare cause of trouble. If the current is broken, both motor and bulb are rendered useless. If the motor stops and the light goes off at the same time, look for a broken connecting cord or blown fuse in house circuit. If the mechanism is running, but the film is stationary, you may expect torn perforations. This is more common in substandard film than in standard, and is most frequent in claw driven projectors. The standard film projector will pass the film even with some perforations gone.

Screen Goes White—This always occurs at the end of projection as the film passes through the

gate, but when it occurs in the midst of a reel it indicates broken film. Stop projector and rethread. Look for piled up film.

Film Chatters in Gate—The emulsion from fresh film is inclined to deposit itself upon the film race in the gate. This gummy deposit grips the film and retards motion. In bad cases the film will dance upon the screen and at times it will go into and out of focus. Remove film from gate and scrape the deposit from the film race. Use a horn pallette knife or similar object for this purpose. Never use steel or any material hard enough to scratch the race, as a scratch will act as a chisel to cut more emulsion from the film and so make the trouble worse.

Projector Runs Slowly and Irregularly—Unless the current has been cut down too far this means that oil is needed. The projector must be kept properly lubricated, and no bearings allowed to become dry. However, too much oil is as bad as none. If oil is allowed to get upon the film, a spot will result.

Take-Up Fails—If the film piles up between lower sprocket and the take-up, something is wrong with the take-up mechanism. If the take-up spindle is stopped, the drive is broken, but if it turns slowly, stopping at the slightest tension, the clutch is not working. Where a slip belt is used, it will often prove that an excess of oil has made the pulley too slippery. A spring belt is seldom subject to this fault, but rubber and leather belts fail in this manner quite often. In the case of portable projectors using a clutch take-up, an excess of oil may be the cause. Remove clutch, cleanse thoroughly in gasoline and replace.

Screen Shows Circular Shadows—Condenser is not properly adjusted. If the shadow is complete and concentric the condenser is centered but not the right distance from the lamp. If the shadow is only upon one side, top or bottom of the screen, the condenser is decentered and the lamp must be moved until the shadow disappears or becomes concentric.

Image Dull and Gray—Lenses dirty. Clean all lenses thoroughly and if this does not remedy the fault, there is something wrong with the light. Advance rheostat to allow more current to pass.

Image Streams Down Screen—At times the image may appear as though it had been dyed upon the screen and then run. The shutter is not properly set and is remaining open while the film is in motion. Adjust shutter so that all light is cut off from screen while the film is in motion.

If the projector is kept clean and properly lubricated, very little trouble will be given. However, the films will have to receive some care if they are to last very long. Films should be given a periodical inspection. During this inspection, all faults are removed, especial attention being paid to broken perforations. When standard film is used the perforation is trimmed as shown in the accompanying cut, but in the case of the substandard film, it is really better to remove a frame of the film and make a complete patch. This patching is identical with the cutting and joining explained in the chapter devoted to edition. In fact, the editing room is the ideal place for film inspection and repair.

The film may be polished during inspection,

just as has been explained in the chapter on laboratory work, while occasional treatment with film preservative is a good idea. This preservative may be purchased from dealers and applied with a chamois pad as has been explained in regard to polishing, except that both faces of the film are treated. Some film cleaners are made in which a hinged block lined with chamois is clamped over the film and the film pulled through it.

Repairing torn perforations. When one, two or more perforations are torn they should be trimmed as shown here

When the film has been inspected and repaired, it is stored. All film, of whatever size, should be stored in humidor cans and these, in turn, in metal cabinets. They should be protected from heat, from excesses of humidity and dryness and from extreme changes in temperature.

Some attention must be paid to the proper selection of the screen. Motion picture screens are made in white, silver and gold surfaces, fine, medium and coarse textures, and opaque and translucent.

The white screen is quite satisfactory and the most inexpensive of all. However, the added brilliancy gained by the use of a properly pre-

A badly torn film with repair indicated.

pared silvered screen is worth the difference in price. The gold screen is used to secure softer effects than can be secured with the silver screen. Black and white films appear to be very

harsh when projected upon the silver screen and for this reason most ordinary exterior shots are printed upon a yellow or amber film base. This is not generally known, as the yellow film has no decidedly apparent color when projected. The use of a gold screen will give approximately the same effect with a black and white print. However, in the case of shadowy interiors, a

The Bell & Howell projection filters enable the owner to project his films in any tint desired. This adds greatly to the quality of the projected image.

lavender base is commonly used, but when this is projected upon the gold screen the effect is not just as good as it might be. For this reason, the user of standard film or of printed substandard positives should use the silver screen and tinted base film, while for the substandard operator who uses the orthodox reversed film, the gold screen will no doubt have great appeal.

The translucent screen is used in any case where it is desirable to locate the projector at the rear of the screen. It must be noted that

in ordinary projection the film is threaded so that the image in the gate is upside down and the emulsion side toward the light source, but when the translucent screen is to be used, the film should be threaded with the emulsion facing the lens. With the translucent screen with projector in the rear, the picture is transposed from the usual position, hence the necessity for the change in threading.

The translucent screen is also widely used in daylight projection. If the screen be mounted in a shallow, black lined box, and the space between the projector lens and screen covered to keep all extraneous light from falling upon the rear of the screen, quite satisfactory results may be obtained from daylight projection.

Chapter Twelve

SOME TYPICAL PROJECTORS

Some of the better known American projectors available for commercial and amateur cinematographers are:

Wyko Projector. This projector projects still pictures made upon movie film. With the Sept camera it makes an ideal outfit for making and showing film slides.

DeVry Projectors

As the DeVry projectors are made in three models, the Regular, the Super and Junior, it may be best to consider some general principles and then to take up detailed specifications.

The DeVry projectors are made for service and to that end are made as simply as is consistent with the finest results. No trimming or fancy trick devices are used. Some special DeVry features are:

Intermittent—Star cam, made to a limit of 2/1000ths of an inch in size. The bearings are hand lapped and the whole intermittent of the finest hardened steel. This insures long wear and satisfactory service.

Film Stop—DeVry projectors have a special filter for single pictures. This filter does not deteriorate as did the older gold-glass filters used for this purpose.

Oiling—The DeVry is oiled in just six places. Three front bearings, two motor bearings and one tube which provides lubrication for all concealed bearings.

Lamp House—Lamp instantly accessible with a three motion support allowing lamp to be centered with condenser instantly.

Visible Operation—By the means of special windows in the case, the mechanism and reels can be seen at all times. This allows the operator to see that everything is working properly at all times.

Suspension—The motor and mechanism are mounted upon a rubber cushioned plate. This protects the mechanism from shocks, jars and so forth. It also enables the projector to remain rock steady while in operation.

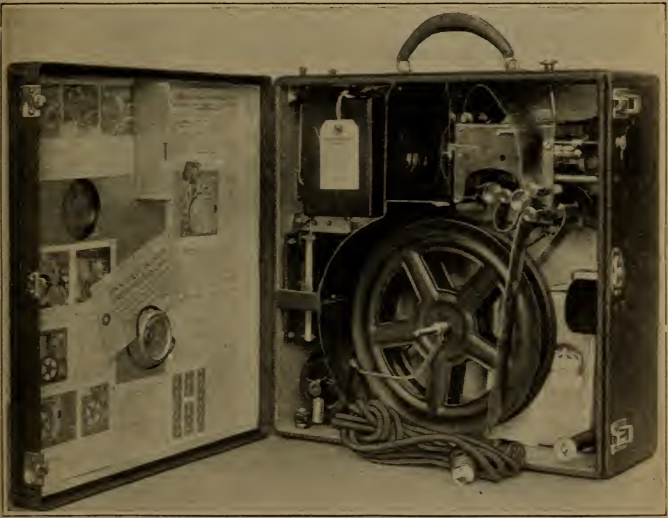
Optical Alignment—Reflector and condenser are permanently aligned. Centering is accomplished by moving the lamp. This insures the utmost in illumination. Both reflector and condenser are instantly accessible for cleaning.

Control—Motor by one switch, light by independent switch, frame by lever on top, focus by button in front, intensity of light by rod at top. Full control is given by the minimum possible number of adjustments.

Case—4 ply wood. Will support five hundred pounds. One of the strongest cases ever used for this work.

Safety—Every possible device has been used to minimize the danger of fire. In consequence the DeVry is one of the safest projectors ever built.

Lens—Special lenses of the highest quality are provided.



The DeVry projector, one of the most favorably known of the standard gauge, suitcase types of motion picture projector.

DeVry Type E

Case—Asbestos lined, leatherette covered.
Size—17x17x7 inches.

Weight—25 pounds.
Rewind furnished.
Current—100-125 volt A.C. or direct. Also adaptable for 220 to 250 volt current. Also in type EU for either 110 or 32 volt current, interchangeable.

DeVry Type S (Super DeVry)

Designed for full brilliance with long throw as in auditorium.
Case—As type E.
Weight—38 pounds.
Current and Bulb—110 volt current with 110V 1000 watt projection bulb or for 110V for either 600 watt or 900 watt, 30 volt bulbs.
Film Stop—Without stopping motor, providing positive ventilation at all times by motor fan.
Clutch—Multiple disc, positive.
Positive Engagement—12 to 16 perforations engaged at all times.

DeVry Type J, for home use and short throws. Same general specifications as Type E.

Holmes Projectors

While the Holmes projectors may be transported from place to place, they can hardly be classed as portable machines. In fact they are fully professional, and are ideal for the small, permanent installation. Like the DeVry they will give full satisfaction.

The projector is of somewhat orthodox design. The reel cases are above and below, with the head between them, permitting a straight line film travel. Other features and specifications are:

Size—Folded for transport, in case 11x17x22.
Weight—37 pounds.
Capacity—1000 feet standard gauge film.
Drive—Motor connected by means of shaft drive, no belts or chains used.
Take-Up—Adjustable if necessary.
Magazines—Solid, all metal, equipped with 4 roller safety trap.
Safety—Film exposed less than 1 inch in its full path of travel. Film metal enclosed when projecting.
Illumination—Any lamp including the largest projection mazdas.
Stop Film—Heat filtering shutter operates automatically when projector is stopped to show "stills."
Stereopticon—No moving of lamp or house. Cooling such that slides cannot be cracked. Attachment is really integral but can be removed instantly.
Rewind—Direct motor driven.
Voltage Change—Lamps and motors interchangeable so that rheostats are eliminated. May be used with 110, 220 or 30V.
Ventilation—Forced.

The manufacturers especially recommend it for churches, schools, clubs, manufacturers' use and so forth.

When travelling, the upper magazine folds down against the film head, making the machine quite compact. It is arranged for table use, although a telescopic stand may be used. It is fitted for slide projection as well as for motion picture projection. In other ways, aside from its small size and compact design it is quite similar to the usual standard theatre projector.

There are several other projectors upon the market, most of them satisfactory, and most of them similar in design to either the Holmes or the DeVry. Then there is the skeleton projector as represented by the Hall, the Ernemann, the Ica and others. They are not in much favor as they are too light for other than purely amateur and home work, and in this field in America the small films are almost universal.

Miniature Projectors

Miniature projectors are made in several sizes: 17.5 millimeter, 16 mm., 12 mm., 9.5 mm., and so forth. To all intents and purposes, the 16 mm., and the 9.5 mm., are the only ones used in this country at the present time. The 16 mm. projectors are represented by four types at present, the Bell & Howell, the Kodak in two models and the Victor.

Bell & Howell 16 mm. Projector

This machine is built of the fine materials and with the exquisite workmanship which characterizes all of the B & H products. If not the supreme type of small projector, it is, at least, not surpassed. Like the Bell & Howell Filmo camera it is also remarkable for its flexibility.

Weight—Alone 9 pounds, with case, spare reels, etc., 14¼ pounds.

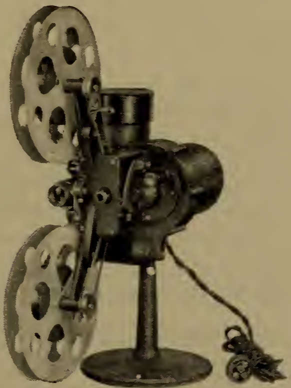
Size—Packed in case 8x11x11.

Capacity—Reels of 1000 screen feet.

Optics—Finest quality projecting lens. Ground plano-convex condensers, and mirror reflector.

Projection Lens—Micrometer mount, any focal length from 1 to 4 inches, all interchangeable in standard mount.

Movement—Shuttle, 9 to 1, actually produces better screen quality than standard theatrical projector.



The Bell & Howell Filmo projector for 16 mm. substandard film. This is one of the finest small projectors manufactured.

Shutter—216 degrees opening. This with 9 to 1 movement gives tremendously increased illumination without increase of lamp power.

Motor—110 volt, universal, integral part of machine.

Control—One, for both lamp and motor.

Cooling—Forced feed air draft cools entire mechanism and allows single frame projection without film warp.

Lamp—50 volt, 200 watt, centered filament, easily replaced.
Rheostat Integral—Automatically cooled.
Speed Control—By convenient knob.
Reels—Standard 16 mm. type.
Clutch—Engages while motor is running.
Reverse—Instant by switch button.
Rewind—Integral.
Stop Film—Film may be stopped at any point.
Safety—Forced cooling, non-flam film, auto light stop, all contribute to safety.

What more can be said? It has all adjustments and controls which can be asked. Interchangeable lenses, brilliant illumination, forced cooling, film stop, film reverse, speed control, and compact design. Its tremendous popularity is evidence of its success.

B & H Accessories

Splicer—Press, knife, water and cement bottle.
Rewind—Usual type altered for small films.
Editing Outfit—Rewind and splicer on one base.
Screens—Opaque and translucent, in all sizes.
Lenses—1", 1½", 2" 2½", 3", 3½" and 4".
Case—Special case incorporating daylight screen is available.
Geared Rewind—For quick rewind.
Special Condenser—Increase in illumination of 25 to 50 per cent.

Eastman Kodascopes

The Eastman Kodascopes are made in two models, one of them a complete projector with all necessary controls and adjustments, and the other a simplified model.

Kodascope

Size—18½ x 15 x 10½ inches.
Weight—20 pounds.
Capacity—400 lineal feet or 1000 screen feet.
Lens—2″ focus, finest quality.
Current—110 volt house current.
Lamp—Either 14 volt, 56 watt or 50 volt, 200 watt. Control by special rheostat and ammeter which are integral.
Frame—By special screw.
Rewind—Manual.

Kodascope Model C

Size—5½ x 7 x 8.
Weight—9 pounds.
Focus—Spiral lens mount.
Framing—Lever actuated.
Stop Film—Lever actuated for still pictures.
Capacity—400 lineal feet, 1000 screen feet.
Lamp—100 watt, 115 volt, special.
Current—110 volt house current.
Rewind—Manual.

Both Kodascopes are well made, of good design, and of the usual Eastman quality. Either will give full satisfaction, but for extreme projection size the larger model should be used with the 200 watt lamp.

Victor Cine Projector

Size—6 x 10 x 14 inches in case.
Capacity—400 feet lineal, 1000 screen feet.
Optical System—3 lens condenser, 2 lens projector and mirror reflector.
Movement—Claw drive, unilateral.

Drive—Motor driven, with control lever on base.
Lamp—50 C.P., 14 volt, double contact automobile type.
Current—110 volt house current.
Control Switch—One for both lamp and motor.
Rheostat—In case, with variable control.
Reels—Standard 16 mm. type.
Rewind—Manual.
Shutter—Enclosed and flickerless.
Take-up—Permanently adjusted spring belt.

The Victor projector is quite inexpensive, but it has proven entirely satisfactory in use.

The Pathex Projector

The Pathex projector is unique in many ways. It has no sprocket drive, the film travel from the reel to the take-up, being produced by means of the central, double claw alone. The take-up is provided with a rubber grip which grasps the free end of the film and pulls it automatically into the take-up mechanism. These two features make possibe an almost instantaneous threading. It is possible to **rewind** the projected film, remove the reel, substitute a new reel, thread the projector and resume projection with the screen dark for a period of only ten seconds or less. This means that for all practical purposes projection is continuous. The projected film cannot be removed from the projector without rewinding. This insures that all films are always ready for projection, and as the rewinding takes only three or four seconds, due to the built-in, geared rewind, this is no drawback. Also the films are projected from and stored in completely closed metal cans, with an opening only large

enough to permit the withdrawal of the film. These are more truly magazines than reels. They insure the fullest protection for the film.

In projection, the film is automatically stopped at any desired points. This is accomplished by cutting a small notch in the edge of the film, and in operation the projector mechanism con-

The Pathex Projector, the smallest practical motion picture projector available.

tinues operating, but the claw is withdrawn to a position where it cannot engage the film perforations. Thus all titles are made upon two or

three frames, and any kind of still scene may be introduced into the action without being perceptible beyond the fact that there is no motion visible. This is of particular advantage in scenic and travel work, as it means a saving of from 30% to 50% in film costs.

Pathex Projector

Size—4x7x13 exclusive of motor.
Capacity—60 linear, 150 equivalent feet.
Optical System—Mirror reflector, plane convex double condenser and finest quality projection lens.
Shutter—Cast integral with balance wheel.
Motor—110 volt, detachable, sensitive resistance control.
Switch—In connecting cord.
Control—Light and Speed by separate rheostats.
Lamp—New special high intensity.
Current—Usual 110 volt house current.
Reels—Special magazine type.
Film—9½ millimeter gauge.
Take-up—Rubber film grip, slip belt drive.
Stop Film—Manual or automatic.
Rewind—Geared integral.
Movement—Double claw engaging two central perforations at once.
Drive—Electric motor or manual at will.

The Pathex projector is the smallest and most compact electric driven motion picture projector made. The films are also very compact, the 60 feet reels measuring about one-half inch thick, about two and one-half inches in diameter with a screen time of from four to seven minutes.

Chapter Thirteen

SPECIAL METHODS

There are many times when the work in hand requires some special methods, for its successful performance. These methods may range from the use of a simple filter to intricate trick work. However, in this chapter we shall only discuss the more simple phases, leaving trick work for a chapter of its own.

We must realize that the photographic emulsion has a range of sensitivity which only overlaps the range of sensitivity of the eye. The emulsion is "blind" to many colors which we see, while the eye cannot see the rays which affect the emulsion the most quickly. The old "Normal" emulsion was sensitive to only blue of the visible spectrum, and those colors which had blue as a component. Later emulsions, such as we now find in common use, are somewhat orthochromatic, that is they are sensitive to the visible rays above the red. And, by the use of certain sensitizing dyes, we can produce an emulsion which is panchromatic, that is, it is sensitive to all visible color.

When an emulsion is said to be sensitive to a certain group of colors, it means that any of those colors will produce an impression upon the plate, but it is also understood that these emulsions all react more rapidly to the blue group than to the red group. In fact, because of this fact we cannot take full advantage of these special emulsions unless we also use a

"filter" or "color screen" which holds back the blue rays and allows the less actinic rays time to impress themselves upon the emulsion.

So we find that the special emulsion should be used with the filter to secure proper color values in monochrome, but as the filter holds back the blue and adds nothing to the quality of the light, it is also apparent that the use of a filter with an emulsion which was blue sensitive only would increase the exposure and do nothing more. So we see that special emulsion and filter are complementary. The emulsion is the positive factor, the screen the negative.

As a rule, only standard stock will be used by the cinematographer, but this has a decided orthochromatic quality, so that the lighter yellow filters may often be used with great advantage. The action of the filter is best explained by calling to mind the "sky-filters." Ordinarily, a clear blue sky with unshadowed white clouds will print as blank white. This is because blue is our most actinic color and the greater the action of any light ray upon the negative the less will be the density of the tone **in the positive!** In other words, the most active colors give us white in the final positive while inert colors give black. So we find that under usual conditions pure blue gives even whiter whites than does a real white, while a deep crimson will give us a deep, soft black.

Now if we make use of a yellow filter, this filter will present considerable opposition to the passage of blue rays, but will allow white to pass readily. In consequence we will find the clouds are represented by dense opacity in the negative, while the blue sky is perceptibly lighter

in tone. In the print, this will give us white clouds, with a perceptible tone in the sky itself. The same result is often used for other purposes, but briefly the filter gives a representation in monochrome of color value which is nearer our perception of relative color value than we find in the usual photograph.

For special work, including much scientific work, the use of panchromatic film with its specially designed filters will give us a very accurate color value scale, in which deep blue will actually appear darker than a bright red.

For such work as the foregoing, these accessories are known as orthochromatic filters and emulsions. The word itself means right color or true color. There are, however, other uses for filters. One of the most common of these uses is haze penetration.

Everyone who has spent time in mountainous countries or who has viewed a city from a high tower is familiar with the phenomenon of haze. The haze of the mountains is purely light haze while in the city, smoke and other vaporous suspensions are responsible. The light haze is due to the breaking down of the blue light rays. The blue rays are the shortest of the visible rays and the most easily refracted. As most natural colors are complex mixtures rather than pure primary, secondary or tertiary colors, any hue we see has at least a tincture of most of the spectral colors. So the image of a distant mountain range is composed of all colors in various proportion. This image is made possible by the light rays reflected by this range, and such rays must travel from the mountain to the eye before the image becomes possible. Before the eye is reached,

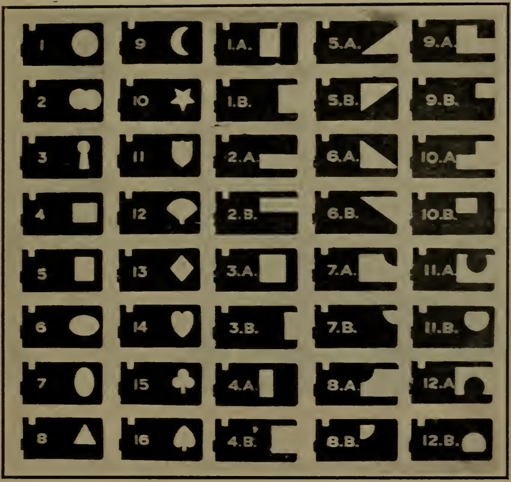
however, many of the blue rays have become bent and scattered so that all image form is lost and we perceive only a slight bluish haze. Fortunately the stronger rays reach us undistorted and we see the mountains through the haze, but as the emulsion is blue sensitive, we find that our photographs are dim and foggy. In short, we have photographed the haze rather than the mountains.

Now if we use a panchromatic emulsion and a deep red filter, we exclude all of the blue and photograph the mountains by means of the long rays only. When this is done we find that we have secured a wonderfully sharp picture, entirely free from haze and more brilliant and distinct than the view ever appears to the eye. But as such a filter requires an extremely long exposure, its use in cinematography is practically out of the question.

This haze is an even greater problem to the aerial photographer than it is to the mountain photographer. After much research, a colorless filter, known as the aesculin filter, has been developed. This filter allows a much more rapid exposure than does the red, but it also cuts off the blue haze and allows the photograph to be made as with the red filter. This filter can be used satisfactorily in cinematography.

This brings us to the question of filter factors. The factor of a filter is that number which indicates the exposure as compared with a normal exposure. Thus a three times filter requires three times the exposure which would be required under the same conditions without the filter. It must be remembered that the filter factor is not a fixed quantity, but varies with

the emulsion in use. For example the K3 filter has a factor of 4½ when used with panchromatic emulsions, but it has a factor of 25 when used with ortho or isochromatic emulsions. Then the red filter "F" has a factor of 24 used with a

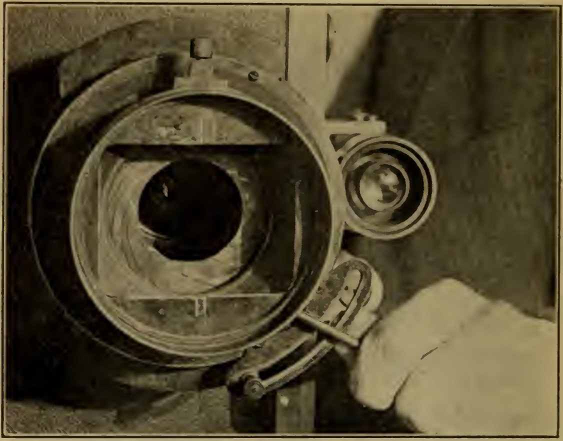


Camera masks. These are used to protect certain areas of the film surface from light. Used for producing fancy shapes and for multiple exposures.

panchromatic emulsion and a factor of infinity used with any other emulsion. That is, it cannot be used with any other emulsion, as it passes red rays only and other emulsions are not affected by red.

Other filters used in cinematography are the "effect" filters. These filters give fog effects, vignetted effects, and so forth. They are not

photographic filters, but are merely screens used to add a certain art effect to the picture. They are quite valuable in all forms of cinematography.



Goerz combination outside iris dissolve and mask box, as used upon the standard camera. This device is also used in various kinds of trick work and is an invaluable accessory.

Another device commonly used is the mask. Masks are used either in the camera mask slot, in which case they give a clear cut margin, or they are used in the mask box before the lens in which case they give a diffused margin. Most standard gauge cameras have mask slots, but few of the miniature cameras are so equipped. For the latter, the Goerz iris and filter holder allows the use of front masks, while standard cameras may be so equipped with the Goerz

standard iris and mask box. Masks are used for three purposes: first, the circular or oval mask is used for "framing" effects, usually with a close-up of a single person. They are used for "fancy" effects such as showing a view presumably through a telescope (circle), binoculars (two intersecting circles), keyhole (keyhole shape), and so forth. Of these two uses the first is usually secured with a front mask while the

The Wollensak amateur iris as used on Cine Kodak and other amateur cameras. It serves the same purpose as the standard iris dissolve.

latter make use of slot masks. The third use is in multiple exposures which will be explained in the discussion of trick work. The use of the mask does not in any way affect the exposure. It merely prevents certain portions of the emulsion from being affected by the light.

The commercial cinematographer will often find that a single lens will not do everything desired. For this reason a battery of lenses is quite desirable. In many cases a camera such as the Institute Standard which carries four lenses ready for instant use, will prove a great convenience. In any case a camera should be selected which has provision for convenient lens

change. The Eyemo and DeVry are so equipped, among the standard automatic cameras, while among the miniature cameras, the Filmo is an outstanding example.

Usual cine lenses range in focal length from 20 millimeters to 7½ inches for the Filmo, 16

The Bell & Howell Filmo outside iris, used for iris "circling" effects just as Goerz standard and Wollensak amateur irises.

millimeter gauge and from 27 millimeter to ten inch for standard cameras, although lenses up to 24 inch focal length are not uncommonly used in standard work.

Lenses of extremely long focal lengths are difficult to use due to the fact that atmospheric disturbance becomes very evident and because the camera must be supported in absolute rigidity. The explorer and naturalist groups form the great majority of users of such lenses. For ordinary commercial use with standard gauge

cameras, lenses of not more than six inch focal length should be used.

The following list gives the more valuable lenses used in standard cinematography. For use with small cameras, such as the Filmo, lenses of just about half the given focal length will give the same approximate results. For example, the 2″ lens may be regarded as normal for standard use and the 1″ as normal for substandard use.

30-32-35 millimeter—Such lenses are used as wide angle lenses. They are often necessary where the working quarters are cramped and the camera must be used close to the subject. They give a slightly distorted perspective, but not to a really objectionable extent.

2 inch (50 millimeter)—Normal for interior and studio work. The most widely used lens in standard cinematography.

3 inch (75 millimeter)—Normal for news work. This lens gives a large image under conditions in which the cameraman cannot approach the subject closely. It gives an image approximately 50 per cent larger than the 2″ lens at the same distance.

4 inch—Used by travellers and explorers. The image is about twice the size of that secured with the 2″ lens. This is about the limit for use in hand held automatic cameras. For miniature work the limit is two to two and one-half inches. The absolute limit, naturally depends upon the muscular control of the cinematographer.

6 inch—Low power telephoto. Used by travellers, naturalists, and so forth. Used to "steal" shots of events from which cinematographers are excluded. Tripod advisable.

8 inch—Telephoto for naturalists and travellers. Tripod necessary.

Above 8 inch—High power telephoto. Use of tripod essential. Often screens must be used to cut haze and "heat dance."

Soft focus—The soft focus lens must be used with care in cinematography. Due to the great enlargement incident to projection, any considerable diffusion will be most unpleasant. The ideal soft focus motion picture is one in which

A typical motion picture telephoto lens. This is a Wollensak lens for 16 mm. cameras.

the detail is not obscured but which is pervaded by a pleasing softness which seems to be "felt" rather than seen.

High aperture lenses—Lenses may now be secured with apertures as great as f 1.5. This means that under conditions which would require ¼ second exposure with an f 4.5 lens, a fully exposed motion picture may be made at normal speed. Quite satisfactory motion pictures may be made of city streets at night. It must be remembered that these lenses have a very shallow depth of field, and that they must be focussed with extreme care. Such lenses are not advised for use wide open; at their extreme

aperture except under such conditions as render the use of any other lens impossible. The usual motion picture has a maximum aperture of f 2.7, f 2.9 and f 3.5.

So much for special equipment. The commercial cinematographer will be required to do his work under all conditions. The airplane cinematographer is becoming common. This work requires a special support for the camera. The camera should never be pointed toward the front of the machine if it is of the open type. The oil vapor will cover the lens and render a film impossible. The picture should be taken at an angle of about 45 degrees, as the vertical angle resembles a map too much. Also, haze will be a great trouble so that the aerial cinematographer should use aesculin filters. This branch of the work is so specialized that the reader who expects to go into this work should read C. L. Gregory's "Condensed Course in Cinematography" which also has considerable space devoted to aerial and submarine cinematography. In fact such work requires a mastery of the art such as can be obtained only in a high class school of motion photography.

Many cinematographers travel widely. This offers a very attractive field for his work. Travel work may be divided into scenic and human interest classes. The scenic motion picture is a difficult subject to handle. It has been overworked in the first place, then the public are far more interested in other human beings than in any scene, no matter how beautiful, and finally such scenes usually lack the fundamental quality of the motion picture—motion.

On the contrary, the human interest film lies

in a field which has been barely scratched. The enterprising cinematographer will find subjects for his camera everywhere he stops. There are habits and customs, even in our own country, which are most interesting. Again, child life presents an inexhaustible field for this work.

It is in the foreign field, however, that we strike real pay dirt. Travel has a strong appeal for all of us, and that appeal is based almost purely upon the strange customs which are revealed to us by travel. What then could be more fascinating than to preserve a record of these things with which to regale our friends at home? In fact, such films find a ready market for production in theatres.

In travel photography, the first consideration is that of forbidden territory. Other nations are far more suspicious of the photographer than we are, and no attempt should be made to use the camera near military or naval precincts unless permission is obtained. The same applies to photography in public parks and buildings. The owner of the automatic camera will usually find no difficulty in securing the desired permission unless the use of a camera is absolutely prohibited.

There is a very widespread objection on the part of private individuals toward being photographed. This feeling is found to increase as the subjects in question become less civilized. Among primitive races it is often really dangerous to be caught making a photograph of a human subject. This is sometimes pure superstition and sometimes it is a part of the religious convictions of the subject. Now, if such photographs can be made without the knowledge of the subject,

there is no ethical reason why it should not be done. No harm results, and very often a valuable film is secured. There are two ways in which such films may be secured.

The aversion shown is seldom apparent unless the camera is at close quarters. These primitive folk seem to have learned that the camera is not "dangerous" unless it is within a few feet. Thus by using a lens of about six inches we can secure these films without interruption. As the motion picture lens is of comparatively long focus anyway, this will give us plenty of room. However, this makes a tripod almost indispensable, and a tripod is conspicuous. The next method is to use a reflector before the lens. If a double reflector can be arranged so that the finder can be used, this method is ideal, but even with a simple polished reflector before the lens, we can often "shoot blind" and get our subject. When the cinematographer is aiming his camera at a building across the street, the people in front of him will disappear, but they will crowd about his sides and back in curiosity. The result is that the right angled reflector will secure some absolutely natural poses which will be invaluable. Any optician or instrument maker can fix two right angled prisms to camera and finder. Prisms are the finest reflectors. Next are surface polished reflectors and the least valuable are mirrors. Mirrors are prone to give double images. The thicker the glass the greater the separation of the two images. Prisms are expensive, but well worth their cost when one expects to travel abroad.

Films, exposed and unexposed, should be kept in sealed tin cans or cans of other metal. They

should be developed as soon as possible after exposure, and in some tropical countries, development must be done within a short time after

Scene from a motion picture taken under the water. Such subjects, while difficult to obtain, bring the very highest prices from the news companies.

exposure. For this reason, the traveller-explorer who plunges beyond the frontiers of civilization should take with him a complete Stinemann outfit for his film. Thus he can develop each day's

films at night. Once developed, properly fixed and washed and dry, the film is practically permanent.

The naturalist explorer cannot rely upon the innocent deception of the prism. Animals are, in this case, at least, more intelligent than humans. In fact, however, the animal must remain unaware of the proximity of man. So, in such cases the naturalist must depend upon the telephoto lens. The expeditionary naturalist-cinematographer should have a reliable camera, tripod and battery of telephoto lenses. For this particular branch of work there is no camera which can surpass the Akeley. This camera was designed for this particular purpose and it has proven remarkably successful.

Aside from these considerations, travel cinematography presents little difficulty and few new aspects.

In all phases of cinematography, both amateur and commercial, occasions will arise when rapid production is desirable. It is quite feasible to make an exposure in the early afternoon and to exhibit the film that night. In doing such work, the amateur should by all means use the two film process. Here, again, the Stinemann equipment scores. The exposed film is developed in a small quantity of developer which can be discarded after development. It is fixed and washed with permanganate, as has been described. The film is squeegeed with damp absorbent cotton as it is wound upon the drying rack. This removes the surface moisture. Then while drying, an electric hair dryer is used to hasten the drying process. As soon as it is dry, which should be within a half hour after washing, the print is

made, and developed. It is quite within the range of possibility for the amateur to project a film within three hours after the completion of exposure.

The commercial cinematographer can do the same thing, but a little longer time will be required, let us say five hours. This is true because, no matter what the circumstances, the commercial film must be edited and should be titled. By the use of a movable title board, titles can be made and cut in without adding more than an hour to the required time, as they will be developed and printed right with the action film. If the circumstances are known beforehand, most of the titles can be prepared in advance.

As special occasions continue to arise, the cinematographer will find that the demand upon his experience will at times become excessive. The cinematographer must never fail! For this reason the commercial cinematographer in general practice should build up a complete reference library. No one volume, even the largest, can contain all the knowledge which he should have. One of the most complete works available is that which comprises the home study course of the New York Institute of Photography. In fact, the cinematographer who cannot attend the school in person, should avail himself of the advantages offered by this course, as it will aid him in every part of his work.

There are several other works which are of great value. A list of such works will be found in the bibliography.

Chapter Fourteen

TRICK WORK

What a vista opens before us at the very mention of trick-work! There is hardly a single fantastic idea which cannot be given existence upon the screen. The masterpieces of the magicians and wizards form the simplest problems for the cameraman. Trickery in one form or another is possibly the greatest single factor in the success of the modern film.

First of all we must realize that trick work does not necessarily mean supernatural effects. Trick work is used to gain natural effects in an easier manner than would be otherwise possible, to show perfectly natural phenomena which would be otherwise invisible, to add to the artistic quality of the film and for many other purposes aside from making the "night-mare" type of fantastic film.

The second point of importance is that while several volumes could be filled with detailed descriptions and analyses of tricks, the fundamentals of all trick work may be given quite briefly. From these fundamentals all trick work is built just as musical compositions are built from the simple chromatic scale.

In actual practice, the elements are not selected and combined into one trick. This would be on a par with selecting certain building materials and then building to fit the material. The first step is to ascertain the trick which is to be produced.

This is then analyzed, and then, and then only, is the time for the synthesis which will build the completed trick. Thus we will find that with the dozen or so fundamental constituents, it is possible to produce any desired effect faithfully enough to fully deceive the average audience.

These fundamental constituents may be regarded first as camera manipulation and extra camera manipulation. Of the latter we have the photographic manipulation and non-photographic manipulation.

In the camera manipulation we have:

Animation.
Time condensation.
Slow crank.
Slow motion or high speed photography.
Reverse.
Dissolve.
Double exposure.
Multiple exposure.
Stop camera.

In the extra camera manipulation we have, first the photographic processes, the principal of which are:

Traveling matte in printing.
Projection printing.

The non-photographic processes include:

Glass work.
Miniature work.
Property construction.
Mechanical methods.
Electrical effects.

In short, the last group, except glass work and miniature work, are used to deceive the eye as

THE MINIATURE CITY

Note that the plain of this city blends with the distant mountains and dunes which are real.

BUILDING A MINIATURE FOR "THAIS"   Courtesy of the Goldwyn Film Company

well as the camera. The duplication of the genuine is so well done that spectators would scarcely notice the difference. These things will not be discussed as we will confine ourselves to the consideration of those manipulations which deliberately distort the scene as it originally appeared before the camera. Considered in the order already given:

Animation—We have seen that the motion picture is purely illusion and that instead of a moving picture we really have a series of slightly different still pictures. Now if we can photograph a series of still scenes, which are but slightly different, we can make a film which, when projected, will show the same illusion of motion that the ordinary film shows. This process is known as animation.

If we have a series of cartoons, each of which is but slightly different from the preceding one, that is, for example, in which each succeeding cartoon shows the arm lifted a little more than the preceding one, and if we then photograph these cartoons, the film will show these intermittent motions as continuous motion and we have the animated cartoon. Animation may also be applied to toys, dolls, models, diagrams and so forth.

Time Condensation—There are many processes in nature which are so slow that the eye can detect no absolute motion and in which we determine motion only by day to day comparison. Such a motion is that of a growing plant. The process of time condensation makes this motion visible, and shows upon the screen a movement which in actual life may require from six to eight weeks or even longer.

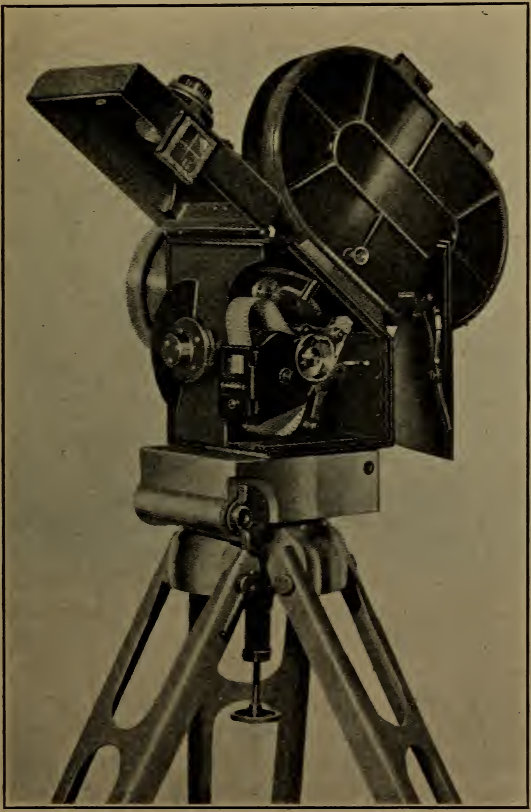
Time condensation is quite similar to animation in that a single frame is exposed at a time, but in time condensation the interval between such exposures must be carefully determined, and the motion instead of being imitated through our control, is natural. We may assume a standard length of five minutes or about three hundred feet for our subjects and into this length we can condense motion which naturally requires any extended period. In fact it is quite conceivable that a motion requiring twenty-five years could be condensed into our five minute film. The formula for computing this interval will be found in the appendix.

Slow Crank—We have seen that a very slow crank, perhaps one single frame each three or four hours, will speed up the screen motion beyond belief, so we may expect that if we crank the one to one crank at normal speed, we shall have a film which shows ordinary subjects dancing about the screen like lightning. This is an old comedy effect. The first traffic snarl shown upon the screen in which all traffic moved at about eighty miles per hour or so, was a big hit, yet the only necessity was a common traffic snarl and a slow crank. We see now that for speed upon the screen we use a slow crank and for slow motion we use a high speed camera.

High Speed Work (Slow Motion)—Slow motion is familiar to all of us. It is one of the most beautiful and attractive effects known in photography. Yet it is very simple. The only requirement is a camera which will operate at approximately twelve to sixteen times normal speed, and which is preferably equipped with 1,000 foot magazines. Proper exposure allowance

must be made for this extreme speed of course, but generally speaking this is only straight work at a highly increased camera speed.

Reverse Camera—This is one of the least famil-



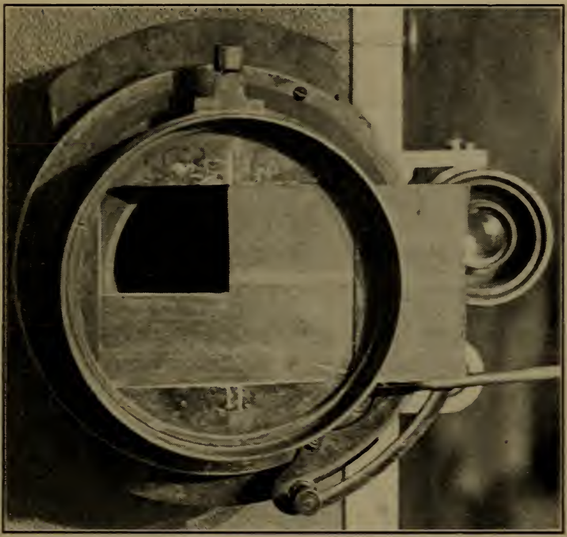
The DeBrie high speed camera, such as is used in making the very attractive slow motion pictures with which we are all familiar.

iar tricks in the amateur and commercial world, yet one which professionals have depended upon for years. It is the most versatile of all tricks as it may be combined with any other, and so simple that it may be performed with any motion picture camera which will expose film, and this without altering the camera mechanism in any way whatever. When pictures are wanted in reverse, and there is no reverse crank, merely turn the camera upside down and you will get your reversed film.

Now what is the reverse? It merely shows all action in reverse. A diver will rise from the water and land upon a springboard, a child throwing apples from a basket into a tree will be catching fruit which jumps at him. A fisherman throwing fish into the water will be catching them as they jump out. A girl gently dropped to the road from the bumper of an automobile which is backing down the road, when taken with a slow crank in reverse, will show us the automobile rushing down upon the unconscious victim, but the hero out on the bumper will scoop her up to safety just in time! Ever see that effect? That brings back the days of Helen Holmes and her trained railroad.

Dissolve—The shutter dissolve brought in some very good effects, but of those the greatest was undoubtedly the lap dissolve. First we must understand that the shutter dissolve works both "in" and "out." Its action is that of slowly diminishing the amount of light which is allowed to reach the film. Now, if we dissolve out upon a scene, we have the common fade-out. However, suppose we fade-out upon on scene, back up the film to the place where we started the fade, and fade-in upon another scene. The two fades are

superimposed and complementary so that there should be no indication of the fade insofar as light intensity is concerned. In this case we have a curious effect. The first scene appears to melt and flow together and from the wreck arises the



Showing the use of cardboard masks in the Goerz mask box for making "split stage" double exposure.

new scene. This was the original conception of the lap dissolve. Now if we fade out upon a scene, and at the finish of the fade we call "Hold!" instead of "Cut," and then reverse to the start of the fade and prepare a lap dissolve,

and then, just before the fade-in, we place an additional actor in the scene and fade-in, calling "Action!" when the fade is half in, we shall get the finest effect obtainable from the lap dissolve. Shown upon the screen, this scene will show no break, but at the dissolve, our extra actor will gradually form from the atmosphere, a true materialization.

The dissolves are also used to introduce visions in conjunction with double and multiple exposure.

Double Exposure—Double exposure means simply that two images are secured upon one film by running the film through the camera two times. If we use masks to separate the double exposures we call it a split aperture, but if both exposures are made upon the full film, it is merely a double exposure.

Let us photograph a landscape with plenty of sky, the whole of rather dull tonal value. This shot is panorammed for about twenty seconds. We now rewind this film, either by reverse if the camera is so fitted, or by taking the camera to the darkroom and rewinding manually. Now in the studio, we pose a female figure clad in flowing white draperies, and by using our tilt head tripod with the camera placed upon it sideways, we incline the camera at an angle of about 70 degrees. Now with an off-stage electric fan blowing the draperies and a dull black background behind the actress we again expose the twenty feet of film.

Effect—A ghostly, translucent figure of an angel floating through the air, draperies fluttering in the wind, details plainly visible, but the background detail faintly visible in all parts of

the figure. Here we see how to create ghosts! The cameraman is spiritualist, necromancer, and magus!

Another effect is that where we see tiny figures introduced into a scene, perhaps upon a chair-arm.

This is done by photographing the scene in the usual manner, leaving a space with a black or dark background where the little spectre is to appear. If there is conversation or action between normal and midget actors, notes must be taken as to the footage where such interaction occurs. The film is rewound, the lens masked leaving open only the space for the small actor, and the camera moved back until the image of this actor is of proper size. The second exposure is now made, being sure that the position of the actor's image is correctly placed upon the film. This type of work requires that the camera have a direct focussing device.

A third variation of double exposure gives this effect, or a similar one:

An actor appears upon the scene and shortly afterward he appears in a second place. He talks with himself and in short he takes up the work of two actors. This is split aperture double exposure. The first action is taken with, let us say, the left half of the aperture open. When this action is photographed, the film is rewound, the left half of the aperture closed and the right half opened and the other action photographed. By careful work, it is even possible for the two images to shake hands, but this requires the most delicate synchronism.

The split aperture also gives us the vision. Thus an actor goes to sleep in a chair and dreams,

or he sits and sees visions in the fireplace or in smoke. The place for the vision is determined. If a dream it may be one corner of the frame, if the fireplace or a smoke cloud, a mask must be made which will roughly conform to the shape of the space. In this type of scene, it will be remarked that the vision appears after the scene starts, so we must combine the split aperture with the lap dissolve.

Effect: The actor comes into scene, sits down, lights pipe, blows cloud of smoke, and sees in the smoke a vision. He wipes his eyes with his hand and vision disappears.

Method—The scene is photographed in ordinary until the first smoke cloud is blown. Beforehand two complementary masks have been made whose shape and size roughly correspond with the shape and size of the smoke-cloud. When this first cloud is blown, the scene is faded out, the actor remains motionless, the vision block mask is inserted and the dissolve lapped. The scene is carried on until time for the hand to brush away the vision. The hand is carried to the forehead and held there while a second lap dissolve is perfomed in order to remove the mask. The cameraman must take note of footage readings at start of scene and at start of each lap dissolve. With the beginning of the fade-in of this last lap, the actor's hand is removed from his forehead and appropriate business is carried on.

The vision scene is now prepared and the camera set up. The vision block mask has been used, so now we make use of the scene-block mask, which is just like the vision-block except that it is complementary. Where the vision block was

closed this scene-block is open and vice versa. This scene block mask covers and protects our first shot, leaving unprotected only that portion of the film which was first protected by the vision-block mask.

Behind a capped lens the film is advanced to the place where the first lap began. Here the vision scene is faded in and run through just like any ordinary scene, being faded out at the proper footage. This completes the work.

Note! The vision action must be so arranged that it will all occur in the proper space. This requires a direct-on-film focus, or a matched range finding finder. Also, the vision fade-in should begin a full two feet later than the lap fade and likewise at the end the scene fade-out should begin two or three feet before the lap fades. This gives a fine dream effect.

Similar effects can be secured without the laps, using camera stops, but this effect is too abrupt for our conception of dreams.

Multiple Exposure—Multiple exposure differs principally from double exposure in that three or more exposures are made upon a single film instead of only two.

Stop Camera—If we stop the camera in the midst of a scene and insert some object and then continue, that object will suddenly appear from nowhere in the scene. This is often used for comic effects in which an actor reaches for a dish or a stein of beer which eludes his grasp just as he closes his hand upon it. This is done by stopping the camera and moving the stein to some other part of the table. It is also used to introduce spectres, ghosts, supernatural figures, visions, dreams and so forth. In this as in

the lap dissolve all actors must remain stationary during the manipulation or the illusion will be destroyed.

The Traveling Mat—The traveling mat is quite within the ability of the usual amateur provided he has a good printer, preferably of the step variety. Let us say that we wish to show the progress of a tank down Broadway. First we must secure our shot of Broadway. This is an ordinary shot, except that we set the camera so that the center of the street shall cross the film at a predetermined angle. Let us say that the center of the street extends from the lower left corner of the frame to the upper right corner. We now arrange a miniature set with a pure white background. We photograph a toy tank traveling a path which upon the frame corresponds to the center line of Broadway, except that we start the tank in the distance and bring it into the camera. This shot is made upon a separate piece of film.

These films are developed. We have a negative of Broadway and one of the tank with a black background. These are known as 1 and 2 respectively. 2 is now used for printing. A heavy print is made in which the tank is almost solid black against a clear ground. This is film 3. Now if we print film 1 with 3 placed between 1 and the positive stock as a mask, we shall get a picture of Broadway with a traveling mask, corresponding to the tank. This film (positive) is again printed using 2 as a negative, this prints in the places left by the mask, and we get our desired result.

Projection Printing—By the use of elaborate projection printers, action can be stopped, re-

versed and speed changed at will. This work is too elaborate and expensive for the ordinary worker to consider.

Glass Work—Scenes are painted upon glass. This glass is set up before the camera so that the painted scene corresponds to the actual set, and so photographed. Suited only for use in studios where a thousand dollars may be spent to save ten thousand.

Miniature Work—The use of miniature models will often make possible effects which could not be secured in any other way. By using a soft focus lens, or by using a diffusing screen with the ordinary lens, common toys may be used to screen train wrecks, ocean storms and so forth. Animated models furnish us with many delightful films. Among such films "The Lost World" stands out supreme. Here we have a prehistoric animal loose in London. By carefully matched straight photography, models and animated figures a startlingly real effect was secured.

The remaining phases of trick work belong essentially in the large studio. With those given, it will be possible for the careful cinematographer to build up the most complex of fantasies. On the other hand, many of these effects will be used in the most serious of work. Thus the split aperture will enable us to show a film of a scientific experiment with explanatory text at the bottom. Animation will allow us to animate explanatory diagrams and so forth. There is not one film in a hundred, other than the common picnic or vacation type of film, which cannot be vastly improved by a judicious application of trick work.

Trick Titles

Many novel and attractive titles can be made by one or another of the trick processes outlined. The most usual use of trick methods in title making is the use of the split aperture double exposure. In this case the title is exposed, the film rewound and some object, drawing or design in clay is photographed to serve as a title motif. This work is also done without the use of masks in which case the motif details merge into and blend with the title itself.

Main titles and introductory titles, which are the same in all films of one series or by one maker, may be quite complex, using animation, multiple exopsure and reverse camera with or without other manipulation. The complexity of such titles depends upon the taste, ability and ingenuity of the producer.

Sub-titles may be made quite attractive by the use of the reverse. Letters are formed of dust, flour, iron fillings, or other similar material. When it is photographed the letters are destroyed by the action of a fan, a magnet or other device according to the material used. In effect, we see a mass of particles whirling and blowing about the screen, finally assuming the form of letters of the title.

Animation enables us to make tumbling and falling letter titles, as well as "clown" titles. Sky-rockets rise and turn into letters, human figures turn and tumble and are transformed into letters, stars whirl and dash about and become letters and so forth. The variety is unlimited, and all made by the same method, a vertical title board, cut out figures and patience! Animation is the secret.

With what has been given regarding title making and trick work, there will be or should be but little difficulty in analyzing any trick title. Moreover, any fantastic title effect can be imagined, and by applying the principles given in this chapter, that effect can be screened successfully. There is no imaginable effect which cannot be secured provided you are willing to spend the time and effort involved. You may even go so far as to make natural lightning form your titles, but the process would conceivably require some years of time, but **it could be done.** However, in a studio, a heavy spark coil or transformer would be used, and artificial lightning would be made. This would do the trick in a short time.

Chapter Fifteen

PRACTICAL APPLICATIONS

In practical work, the first thing to do is to prepare a written program to be followed. There is nothing more discouraging and more fatal to success than haphazard work. Before making a shot the entire story should be clearly in mind, and a written synopsis, worked out scene by scene, should be at hand. Then as each shot is filmed, that scene is checked off of this written list. This is the continuity or the "script."

This continuity contains the scene number, the scene title, the estimated footage, a description of the setting and a synopsis of the action. Thus we have the continuity of "Purity Maid Bread." We turn to scene 64 and see something like this.

64—Closeup! Bread entering the oven door. (Abt. 10 ft.) Action starts with loaf entering frame and continued until that loaf has disappeared in the oven.

65—Medium shot! Endless belt carrying loaves from oven to wrapping table. (Abt. 15 ft.)

Title 12 "The loaves leave the oven and are wrapped in waxed paper without being touched by human hands!"

Scene 65 continued.

66—Closeup of wrapper. (Abt. 20 ft.)

Such a continuity also carries the indications for circle in and circle out, also fade in and fade out. In short it is a check list for the director-cinematographer. Such a script is essential in any kind of cinematographic work.

The cinematographer has many fields open to him. Among these are news reel work, engineering records, construction records, scientific films, educational films, training films, community advertising films, commercial record films, family record films, portrait films, films of children and so forth.

The news photographer makes film for use in the weekly news reels. He is in the same class with the skilled reporter and the press photographer. He goes after the human interest work, and ships his films to the editorial offices as soon as they are exposed. His payment varies from fifty cents to two dollars per foot for all film accepted.

News film photography is an art in itself and cannot be fully discussed here due to limited space. For a full discussion of this fascinating branch of cinematography see the New York Institute Home Study Course.

Every engineering contractor goes to great expense to have his records kept up to date. Reports from field engineers are carefully filed and studied. The newer way to file reports is to have them on motion picture film. The principal achievements of the week are shown, while the written reports are also photographed and incorporated in the film. This leaves little room for misunderstanding. The report and picture support and complement each other. There is an increasing demand for engineer-cinematographers. The same thing applies to building construction as to every phase of construction by field crews away from the home office.

The use of the motion picture in schools is increasing rapidly, but the supply of films for

such purposes is woefully inadequate. The scientist and the teacher who will take the trouble to learn cinematography should have no difficulty in finding a ready market for their scientific films. There is no scientific demonstration which cannot be made through the medium of the motion picture and as we have control of the speed in the motion picture, the pictured demonstration is very often superior to the actual demonstration. There is an opening for motion pictures in the teaching of every subject in the school curriculum.

Practically every manufacturer of today uses films in his sales campaigns, while many large merchandising companies use the films in training their salespeople. Large corporations of every kind make use of the films in training workers of various classes. This field alone is making a greater demand for cinematographers than can be met, for in order to fill these positions it is essential that the cinematograher be an expert. All of these specialized fields require that the cinematographer be an expert in the business exploited as well as in cinematography. In short he is analogous to the industrial photographer.

These specialized fields require special equipment. For example let us suppose that the work in hand requires motion pictures of microscopic objects as in scientific work.

In this case we should probably make use of the Zeiss-Ikon apparatus. This consists of a special model of the Ica Kinamo motion camera, with a capacity of 80 feet of film. In addition there is a special laboratory stand for the camera, an attachment for connecting the microscope and the camera, an optical bench with lamp, lenses, iris

rings, cooling tanks and so forth, also a special arc lamp and resistance for illumination. In addition to this apparatus we require a good compound microscope with fluorite objectives. This apparatus is now set up according to maker's directions and fine microscopic films may be secured. It will be seen, however, that a small pocket manual cannot cover the whole field, in fact the true purpose of such a work as the present is to indicate the vastness of the field, and to aid the newcomer in choosing the particular portion of this field to which he will devote himself, and to then aiding him in starting upon this specialized work. The successful cinematographer must be a specialist.

The commercial cinematographer will do work which is similar to that done by the commercial photographer. He is the industrial photographer for those firms which are too small to have their own studios, he does the community advertising films for the "Booster Club" and similar organizations, but instead of being at the top of his profession as a commercial photographer is, he will rank under the specialists.

One of the most promising fields, which has all of the attractive features of the portrait field, and which is even more lucrative, is the field of motion portraiture. This ties up with the field of child cinematography and family record work. The portraits are supplied either as films or as cabinet enlargements from the best single poses. Such films usually bring the cinematographer as high as five thousand dollars for a single week's work.

However, the work is the thing. When the reader has mastered the actual operation of mak-

ing motion pictures, he may study his inclinations and ability, he may study the field before him and conclude that there is one particular branch of the work which will suit him better than all others. By this time, however, he will have progressed far beyond the work outlined by this little manual and should have studied and mastered every text and reference which bears upon this work which he has chosen.

This manual is no more than an introduction to cinematography. In order that the interested student may follow up the study of the art, a bibliography is included.

APPENDIX—BIBLIOGRAPHY

The cinematographer cannot expect to master his chosen profession without close application and serious study. In order to aid him in the selection of the works best suited for such purposes of study, this brief bibliography is given.

"PROFESSIONAL CINEMATOGRAPHY"
Herbert C. McKay, A.R.P.S.

This is the home study course issued by the New York Institute of Photography and is encyclopedic in content. It covers in detailed form every phase of cinematographic work.

"CONDENSED COURSE IN MOTION PICTURE PHOTOGRAPHY"
By Carl Louis Gregory, F.R.P.S.

This is one of the greatest text books ever published dealing with this subject. It gives the student a firm theoretical grasp of the subject. The author is recognized as the Dean of Cinematographers.

"MOTION PICTURE PHOTOGRAPHY FOR THE AMATEUR"
By Herbert C. McKay, A.R.P.S. Director of the New York Institute of Photography and Editor of Motion Picture Department of Photo Era Magazine.

This is a brief discussion of the amateur field, with full directions concerning every phase of amateur work, planned to enable the amateur to produce successful films from the first.

"PRINCIPLES OF PICTORIAL PHOTOGRAPHY"

John Wallace Gillies

This is an essential part of every photographic library. No matter how highly technical quality may be developed, the photograph lacks something vital if it is not pictorial. A close study of this book will be of great aid in developing the latent pictorial sense of the cinematographer.

"MOTION PICTURE DIRECTING"

By Peter Milne

The amateur cinematographer and the commercial one cannot depend upon a legion of assistants, each must be his own entire staff. For this reason these new cinematographers must become familiar with every phase of this work. No better text for the new director can be imagined than Milne's great book.

"PHOTOPLAY WRITING"

By William L. Wright.

This is not a text for the dreamer who aspires to millions over night. It is a practical, sensible treatise, which shows clearly just how the continuity should be prepared. It is a money and time saver for the cinematographer.

"SCREEN ACTING"

By Inez and Helen Klumph

This work continues the series described above. A study of this book will enable the new cinematographer to secure the very best from his amateur actors. The book is packed full of valuable information.

"MOTION PICTURE PROJECTION"

T. O'Connor Sloane, Ph. D.

Doctor Sloane has given us here a complete, understandable treatise upon the subject of projection.

"PHOTOGRAPHIC TECHNOLOGY"

Herbert C. McKay, A.R.P.S.

This is an exhaustive treatise of the laboratory with its equipment, supplies and work. Every laboratory worker should study this work which is a complete course of instruction in itself.

All of the above books can be secured through the Falk Publishing Company, 10 West 33rd Street, New York City.

FILM PUBLISHERS

In addition to the larger, well known film producers, the following firms produce or publish films. Inquiries as to the character of films desired may be addressed to the firm directly.

Atlas Film Company—Oak Park, Ill.
Apollo Film Co.—286 Market St., Newark, N. J.
Beseler Film Corporation—71 West 23rd St., New York.
DeVry Corporation—1111 Center St., Chicago.
General Vision Company—104 West 42nd St., New York.
George Klein—49 West 45th St., New York.
Pilgrim Photoplay Exchange—1150 South Michigan Ave., Chicago.
Society of Visual Education—327 South LaSalle St., Chicago.
Visual Text Book Publishers—212 West 11th St., Los Angeles.

GLOSSARY

Like nearly every other art, cinematography has a slang or patois of its own with many words or phrases which have a specialized meaning different from their ordinary use. For that reason a list of more common words and phrases is given here. This list is not complete. New words and phrases are coined every day. Unfortunately there are many terms commonly used in cinematography that have more than one meaning and even those familiar with the industry cannot know just what definition to assign to them unless the accompanying context gives a clue to the intended meaning.

Action—The events of a dramatic motion picture; the development of a story; the business of the characters which carries on the story; the command to players to start enacting a scene.

Aerial Image—A light image existing in space, rather a difficult conception to the tyro as it is invisible except from a very restricted viewpoint.

Angle, Camera—The angle of view taken by the motion picture camera through the two outer edges of the picture give the camera angle. Occasionaly it may mean the vertical angle of the camera.

Angle Shot—An insert scene continuing the same action but shot from another angle.

Aperture—In speaking of lenses, aperture means the iris diaphragm opening. In speaking of motion cameras or projection it means the oblong hole which frames the picture being

taken (or projected). Do not allow these two different meanings to confuse you.

Aperture Plate—The metal plate around the picture opening in the camera or projector.

Art Titles—Motion picture titles with designs showing in the lettered background of film captions.

Artificial Light—Any source of light not originated direct from sunlight.

Axis, Lens—A line passing through the thickest part of a positive or the thinnest part of a negative lens perpendicular to the surface of the lens.

Back Focus—Distance from rear combination of a motion picture lens to the focal plane.

Backlash—The "play" or looseness of a worn gear train or other mechanical fitting.

Back Light—The so-called Rembrandt lighting where strong light is thrown on the actors from the back—giving a line of light about the outline of the figure.

Balloon—The outline around a spoken cartoon title.

Barrel Distortion—A lens defect which causes the image of parallel lines to bulge outward.

Base—The celluloid component of motion picture film.

Bath—Any chemical solution used in treating photo materials.

B. & L.—Bausch & Lomb—Lens manufacturers.

B. & H.—Bell and Howell Camera.

Binocular—The conventional design of two overlapping circles used to indicate the view seen through field or opera glasses.

Biograph—An old term for motion picture—also one of the first motion picture companies.

Black Maria—Thomas Edison's first studio.
Black Matte—Opaque mask as distinguished from a semi-transparent one.
Bleeding—Distortion of image from oozing color in tinting or toning.
Brief Synopsis—The story of a scenario told in a few hundred words.
Buckling—When film fails to run through camera properly it is said to "buckle."
Business—A definite bit of action. "Business of making love" indicates that character referred to is to make love to some one else designated in the scenario.
Bust—Obsolete term for close-up.
Calibrate—To scale an instrument; generally means marking the focusing adjustment of a lens for objects at various distances.
Cam—The cam which operates the intermittent movement of the film in a cine camera.
Camera—The usual command to the cameraman to start grinding when taking a scene.
Camera Mount—Any kind of camera support other than a tripod; as camera mount on cartoon table, camera mount for airplane.
Caption—A motion picture subtitle in a film or the written wording intended for a subtitle.
Carbons—Arc light carbons.
Cameralite—A very compact arc light resembling a rollfilm camera in appearance and used for making amateur and commercial motion pictures.
Carboy—Large glass bottle for solution or acids.
Cartoon—Often applied indiscriminately to any kind of animated drawing or diagram.
Celluloid—1, film base—2, in cartoon work any drawing on a transparent base is a celluloid or a "cell."

Changing Bag—A light tight cloth bag with armlets in which plates or films may be changed in the open.

Characters—The fictitious persons whose actions make the story of a scenario or play.

Chart 1. In elaborate trick work a graph or chart is sometimes used as a guide in matching exposures.

2. A card with geometrical areas of black and white for easy focusing and for testing lenses.

3. A chart may be any table of figures for quick and ready reference for focusing, timing exposure, mixing solutions, printing negatives, etc.

Chemical Rays—Actinic light.

Chiaro Oscuro—Aerial perspective.

Cinematographer—The expert photographer who operates a cine camera.

Cinching Up—Tightening a roll of film by holding the center and pulling on the outer end. A good way to scratch film and make "rain" marks.

Cinophot—A very precise and scientifically designed exposure meter.

Circle of Confusion—The round image of a point of light not in focus.

Circle In—Same as iris in.

Circle Out—Same as iris out.

Claws—The metal fingers or pins which engage in the film perforations to move it intermittently downward in the camera.

Claw—Slip claw movement, an intermittent movement which slips upward across the film perforations but engages like a ratchet and

draws the film down with its downward movement. Will not work in reverse and is therefore seldom used.

Climax—The supreme moment in a photoplay, the culminating point to which all the action trends.

Close-Up—Anything taken by the movie camera at a distance of four or five feet or less—used alone it generally means head and shoulders of actor but may be used as: close-up of face, close-up of locket, close-up of note book. Close-ups of small articles, letters and telegrams are also called inserts.

Color—Anything which adds to the supposed character of a scene is "color" or "atmosphere." "Color" is a bit higher grade than "atmosphere." In an African desert scene camels would be "color," real Arabs in native costume would also be "color," but supers made up as Arabs would be simply "atmosphere."

Color Screen—A ray filter used before the camera lens to get different tonal rendering of color values.

Color Filter—Same as color screen.

Composition—Arrangement of objects in a scene according to art principles.

Compo Board—Composition board—used extensively for building scenery and for many other purposes in studios.

Concave—Hollowed inwards.

Continuity—The story or scenario as ready for production. Continuity describes the business and action of the consecutive scenes.

Continuous Action—An uninterrupted sequence of action between characters.

Convex—Bulge out.

Contrast 1. In prints is where the shadows are very black and dense and the whites very transparent and chalky.

2. Contrast is also used to indicate opposing emotions and conditions in dramatic action—poverty emphasizes riches, hatred contrasts love.

Cooper Hewitt—The name of the inventor of the green tube lights used for soft lighting in most studios and by which they are designated to distinguish them from other types of lights.

Crank—Command to start turning the camera.

Cranking—Taking the picture.

Crank Speed—The speed at which the camera should be operated to get the desired effect.

Crank Turner—An opprobious or sarcastic name for an indifferent cameraman.

Crepe Hair—Artificial hair used by actors for building up beards, mustaches and shaggy eyebrows.

Crisis—A critical moment in a photoplay but of less importance than the climax.

Cross Lines—Fine lines engraved on glass. Used to locate focal plane in microscopic focusing.

Cut—Stop grinding. Stop the action, end of the scene.

Cut In—Any close-up or insert which is interpolated into a longer shot.

Cut Back—Where two trains of action take place simultaneously, the secondary action is shown in cutbacks. For example, the girl is struggling with the villain and far away the hero rides to the rescue. We see the girl struggling, then the cutback to the hero riding furiously, then to the girl again and so on.

Cutting—Editing film.

Cutting the Negative—Matching the master negative up with the edited first print.

Dark Room—Room where film is developed. It is dark except for dim red lights.

Decorative Titles—Same as art titles.

Definition—The sharpness or clearness with which lights are defined by a lens.

Density—The amount of opaque silver deposit in a photographic image.

Depth—1. Pseudo stereoscopic effect.
2. The range within which objects are in focus in a photographic print.

Descriptive Title—A title used to describe something not shown in the action or to cover a time lapse.

Develop—Bringing up the latent photographic image.

Developer—1. The solution used to develop film.
2. The dark room attendant who develops film.

Diaphragm—The iris like mechanism in a photographic lens.

Director—The person who directs or stages a motion picture production. He rehearses the actors in their parts, tells the cameraman when to shoot and when to stop; is, in short, the construction boss in the building of a picture.

Discovered—A term used to show that a character is present in a scene at the time it starts.

Dissolve—The gradual change of one scene into another, made by overlapping the fade-in of one scene on the fade-out of another.

Dissolve In—Where the picture emerges gradually from the darkened screen. "Fade in" is a better term for this. Made by slowly opening

the lens diaphragm or by a device which opens the shutter blades.

Dissolve Out—Picture fades away to dark screen. "Fade out" is a better expression. The reverse of "dissolve in."

Double Exposure—A composite picture made by exposing the same film twice.

Double Printing—A composite picture made by printing from more than one negative on the same strip of positive film.

Dream Picture—A picture of improbable nature finally explained as being a dream.

Drums—The large reels upon which films are dried after development.

Drum System—Development of films by winding spirally on cylinders which are revolved with the lower surface in the developing solutions contained in troughs or trays. Other systems are rack, pin tray, Stinemann and machine development.

Drunken Screw—The irregular tongue or groove on the cam of the intermittent movement which forces the claws in and out of the perforations in the film to draw the film past the gate.

Dual Role—Where one actor takes the part of two different characters of similar appearance. This is made possible by double exposure.

Duplex—A brand of step printer much used in motion picture laboratories.

Dyed Film—Positive film tinted with colored dye.

Dye Tone—A positive in which the silver image is colored or replaced with dye.

Eastman—The name of the manufacturer of film stock and other photographic supplies.

Edinol—A developing chemical.

Editing Film—Arranging the scenes and titles of a motion picture into proper sequence for exhibition.

Educational Films—A general term for almost any film not of dramatic or comedy nature and does not necessarily mean a film for instructional purposes. Scenic, travel films, industrial pictures, novelty and review pictures are all often classed as "Educational."

Effective Aperture—The concentrating of light rays by the front lens element makes the measured diameter of a diaphragm opening less than its mathematically calculated equivalent. In other words, a diaphragm opening the effect of which is the same as the calculated opening is called the effective aperture.

Elon—A developing agent.

Emulsion—The dull coating of film, plates or paper which is sensitive to light action.

English Weights—English and American weights and measures are not always equivalent. Consult tables for equivalents.

Enter—A term used to designate the entrance of a character on the scene.

Episode—A section of a serial film usually in two reels.

Ernemann—Name of a German manufacturer of motion picture cameras and apparatus.

Ether—1. A term for the intangible medium which pervades the universe and which transmits light, radiant heat, X-rays, radio waves and other vibrations.

2. Ether is the common name of sulphuric ether, a volatile liquid used as a solvent and anesthetic.

Exit—The departure of an actor from the scene.

Exposure—Making the impression on the emulsion by opening the shutter and allowing the lens image to act on the sensitive surface.

Exterior—A scene taken outside of a building. Usually anything taken outside the studio, although exterior sets are not uncommonly built in the studio. On exteriors means working outside the studio.

Extras—A term used to indicate the supernumeraries or "extra" people who comprise the mobs, crowds, guests or other persons who are incidental to the plot of a picture and who are usually hired by the day.

Eye Piece—The lens element to which the eye is applied in any telescope, microscope, binocular, focusing device or other optical instrument.

Factor—A number used to indicate the relation of one thing to another as regards its value for speed, time, duration or any other purpose.

Fade—Fading of the picture to blackness by gradually decreasing the exposure to nothing. Also called fade out.

Fade In—Causing the picture to emerge from darkness by increasing the exposure from nothing to normal.

Fade Out—See Fade.

Fake—Any artificial means for accentuating a desired effect in pictures is called faking.

Farce—Exaggerated comedy.

Fancy Masks—Masks for framing the picture in the aperture plate for decorative effect, such as heart shape, card pip shape, arch way, silhouette, etc.

Farmer's Reducer—A reducing solution the principal ingredient of which is potassium ferricyanide.

Field—The field of a lens in the angular measurement of the view which it takes. A two inch cinematograph lens has a field of about 28°.

Filming—Producing a picture.

Film Stock—Unexposed film, either negative or positive.

Filter—1. A device for straining impurities from water.

2. A colored glass does not transmit certain colors of light, i.e., it filters light. Used to accentuate or suppress the tonal value of colors.

Flash—A very short scene.

Flashback—See cutback.

Focal Length—The measurement from a lens to the image when the object is at a great distance.

Focus—The point or plane in which a lens produces a sharp image. To focus is to adjust the lens so that the image of the principal objects are sharp and in the lens field.

Focus, Back—Back focus is the distance from the outer surface of the rear lens element to the focal plane.

Fog—A fog or veil on a negative or positive; generally caused by light striking the sensitive surface from some other source than the lens. Fog may also be due to deteriorated materials or the action of impure or old chemicals.

Formaldehyde—A chemical used for hardening the emulsion when softened by heat.

Foreground—That part of a picture which represents the objects nearest the camera.

Formula—1. A recipe for compounding a solution.

2. A mathematical equation in which letters represent values to be assigned according to

the problem which is to be solved.

F. System—The method of calibrating lens diaphragms in terms of the focal length.

Free Lance—A cameraman who makes pictures on his own initiative, expecting to sell them later on, or one who accepts temporary assignments for a variety of companies.

Frilling—Separation of the emulsion from its support at the edges.

Fringe—The colored outline of an image produced by an uncorrected lens.

Geneva Movement—An intermittent movement produced by a cam and star wheel. The movement used in most projection machines.

Ghost—1. A ghostly apparition in pictures produced by double exposure.

2.. Blurring produced in pictures where the shutter does not operate in correct synchronism with the moving film.

Gillon—Name of a French maker of cameras and motion picture apparatus.

Glass Work—Trick photography in which pictures on glass are used to take the place of parts of the setting.

Glass, Ground—Glass ground or sand blasted on one side; used for a focusing screen.

Goerz—Name of maker of Cine lenses and camera attachments.

Gradation—The scale of tonal values in a picture.

Graduate—A measuring vessel for fluids.

Granularity—Coarseness in the silver grains in a photographic image.

Grease Paint—The sticks of color used by actors to prepare their faces for screen photography.

Grind—To turn the crank of a motion picture camera.

Halation—The ghostly halo sometimes seen about the image of a bright object in a photo.

Half Tones—The intermediate shades between white and black.

Halo—Same as Halation.

Hand Dissolve—A device, operated by hand, to fade in or out.

Hardener—A solution used to harden photographic emulsion.

Harmonic Cam—The cam used in most motion picture cameras to produce the intermittent movement.

Harvey Meter—A mechanical calculator designed to give the correct exposure when set for the various conditions which affect the quantity and quality of light.

Heydemeter—A light meter for determining exposure.

High Lights—The lightest parts of a picture.

Hood, Lens—A tube or box designed to protect the lens from light not needed to form the image, such as strong side lights or direct sunlight.

Hurter & Driffield—A system of ascertaining the relative speeds of photographic emulsions; named after the inventors.

Hydroquinone—A developing chemical.

Hypo—The photographic nickname for hyposulphite of soda (sodium thiosulphate) or its solution. It dissolves the sensitive silver salt from the image after development and "fixes" it from further light changes.

Image—The picture produced by a lens.

Image, Real—An image formed by a lens or curved mirror that can be shown on a screen.

Image, Virtual—An illusion image produced by

a negative lens. It cannot be shown on a screen as the rays which produce it do not come to a focal point.

In and Out Movement—That part of the intermittent movement which moves the claws in and out of the film perforations.

Index of Refraction—A number which indicates the relative power of different kinds of glass to bend light rays.

Industrial Films—Films showing manufacturing processes and production of materials.

Infra Red Rays—The invisible radiant heat of the lower end of the spectrum.

Instructional Films—Films intended for teaching purposes; instructional is used in a much narrower sense than educational.

Intensify—To increase the density and contrast of a photographic image with a chemical solution.

Interior—Any motion picture scene representing an enclosed space, a studio scene.

Inversion—All photographic lenses invert the image of the object in the camera.

Keyhole—A camera matte having the shape of a keyhole.

Kliegl—A type of hard light for illuminating motion picture settings.

Kliegl Eyes—A burning sensation affecting the eyes caused by the intense light from lamps of the Kliegl type.

Kodak—Often applied indiscriminately to the Eastman Kodak Company and all their products.

Laboratory—A place where films are developed and finished.

Lacquer—Celluloid solutions, either colored or

transparent, with which nearly all camera parts are coated for protection and finish.

Lantern Slide—A photograph on glass for projection on a screen.

Latent Image--The photographic image before development.

Latitude—The range of exposure within which a photographic emulsion will produce a satisfactory picture.

Lead—The leading character in a photoplay, either male or female.

Leader—An obsolete term for subtitle. The blank film at the beginning and end of a reel of film.

Lens—There are lenses of hundreds of varieties for thousands of purposes but the word is used most commonly in photography in referring to the lens which forms the photographic image.

Lens Barrel—The metal tube in which a lens is mounted.

Lens Board—That part of the camera on which the lens is mounted.

Lens Hood—See Hood.

Lens Mount—In many motion picture cameras the lens mount is also the focusing device.

Lighting—Arranging artificial lights or controlling natural light to obtain any particular effect in a picture.

Lighting, Line—See back light.

Loading—Putting film in retorts or plates in holders or threading a new retort into the camera.

Locale—The locality or environment in which a sequence takes place.

Location—Any place away from the studio used as a scene background.

Location Man—A person who finds locations suitable to the scenario.

Long Shot—A scene photographed with the camera set at a distance from the action; a full view.

Loop—The slack portion of film above and below the intermittent claws which allows them to operate without tearing the film.

Lumiere Carpentier Movement—The same as the Pathe or Harmonic Cam intermittent.

Machine Development—Development of motion picture film by automatic machinery.

Magazine—The light tight container for film used on a camera; also called retort.

Magnesium Torch—A flare giving an intense white light used for exterior at night and in caves and interiors where electricity is not available.

Main Title—The name of the photoplay as a whole.

Make-up—Theatrical grease paint and accessories used to beautify or alter the features of actors. Also means role or character as "His 'make-up' is an Indian."

Maltese Cross—The star which is part of a Geneva intermittent movement.

Manuscript—The typewritten story, scenario or continuity.

Mask—A matte used next the film or front of the lens to block out a portion of the picture.

Meter—A measuring instrument. In motion picture photography there are several kinds: light meter, speed meter, footage meter, etc.

Metol—A developing chemical.

Metric System—The French system of weights and measures; it is often used in compounding formulas.

Microscope—Microscopes are often used for ac-

curate focusing and for calibrating focusing mounts.

Miniatures—Miniature sets are often used, generally in conjunction with trick photography, in making scenes that would otherwise be prohibitive on account of expense.

Mount—The part or mechanism which holds the lens barrel.

Movement—The intermittent mechanism of a motion picture camera.

M. Q.—Abbreviation for Metol Quinol, the active ingredients of the most commonly used developing solution for motion picture film.

Negative—The photographic image produced in the camera from which the positive prints are made.

News Films—Films of topical and current events.

Objective—An image forming lens.

Operator—Any person operating a machine, but specifically in cinematography a projection machine operator.

Optical—Pertaining to lenses.

Orthochromatic—Giving correct color value.

Pam or Pan—To revolve the camera to take a panoramic view.

Panchromatic—Sensitive to all colors.

Panorama Head—The revolving device on a motion picture tripod which permits the taking of panoramic views.

Paramidophenol—A developing agent.

Pathe—Name of a French firm which manufactures motion cameras and films.

Pathe Movement—The harmonic cam intermittent.

Pedagogical Pictures—Pictures for school and college use for instruction.

Persistence of Vision—That faculty of the sight which causes an impression of light to persist for a short interval after the light has ceased.

Perspective—That property of a picture which gives the illusion of distance.

Persulphate—A chemical which reduces density and contrast at the same time.

Photo Dramatist—An author who writes photoplays.

Photo Meter—A meter for measuring light or exposure.

Photoplay—A drama in motion picture form.

Pillow Distortion—A lens fault which causes the image of parallel lines to curve inward toward one another.

Pinhole—A pinhole may be used as a lens but the image is faint and diffused and requires long exposure.

Plot—The basic foundation of a story.

Positive—Any print from a negative is a positive but in cine parlance a positive is a print or film from a motion picture negative.

Positive Stock—Unexposed sensitive film intended for printing from motion picture negatives. It is slower and more contrasty than negative film.

Primary Colors—Red, yellow and blue.

Principals—The principal characters of a photoplay.

Prism—-A bar of glass of triangular section.

Printer—A machine for printing positives from motion picture negatives.

Probus Paint—An acid and alkali resisting paint much used in photo laboratories for painting tanks and trays exposed to the action of developing solutions.

Projector—A machine for exhibiting motion pictures on a screen.

Props—Short for properties. In theatrical and motion picture work a property is any article used or shown in a set. Often used to mean an imitation or fake, as prop jewelry or prop vase because imitations often show as well as the more expensive genuine article on the stage.

Property Plot—An itemized list of the articles and objects needed to produce a photoplay.

Pyro—A developing agent.

Quartz Lens—A lens made of quartz. It transmits ultra violet light to which most glass is opaque and is therefore very fast, but the image is soft and unsuitable for obtaining sharp detail.

Rack—The frame on which film is wound for tank development.

Real Image—A lens image whch may be shown on a screen.

Rectilinear Lens—A lens which makes images of parallel lines without distortion.

Reducer—A solution for reducing the density of a photographic image.

Refraction—The bending of light rays by a transparent substance.

Register—To indicate by simulation. An actor registers "hatred" or other emotions in a scene.

Release—Pictures are generally "released" or shown all over the United States on the same date. A release may mean all the positive prints of a certain title.

Release Title—The main title of a picture at the time of release. It may have been produced under a different "working title."

Relief—Comedy or light action to contrast or relieve heavy dramatic action.

Rembrandt—See Back Lighting.

Retake—A scene retaken on account of some defect at the first filming.

Retort—A magazine to hold film in the cine camera.

Retrospect—Reverting to previous action. Such action may or may not have been shown before. Where a character makes a confession or tells something the scene dissolves back to the retrospect.

Reversal—1. Changing an image from left to right as in a mirror.

2. Changing a negative to a positive or vice versa by chemical means.

Rheostat—An instrument for controlling the strength of an electric current.

Rhodol—A developing agent.

Rod and Crank—An intermittent motion obtained with a crank and connecting rod.

Rouge—Red grease paint used in making up.

Scenario—Outline of a photoplay indicating all scenes, business, action and titles, inserts and subtitles.

Scenario Editor—A person employed by a producing company to read all manuscripts submitted and select those suitable for production.

Scene—The action in a photoplay that is taken without stopping the camera.

Scenic Film—Films of scenery and travel.

Screen—The surface on which a motion picture is projected.

Screw, Drunken—The groove or tongue which imparts the in and out movement to the film claws in a camera..

Script—Short for manuscript.

Sequence—A connected series of incidents in a photoplay.

Sets—The painted scenery of an interior location is a set.

Shadows—The darker portions of a picture.

Shoot—Command to start turning the cine camera.

Shot—The film of a scene; as a scenic shot, an interior shot, etc.

Shutter—That part of a camera which opens and closes the lens when making an exposure.

Silhouette—A scene in which only the outline of the characters is seen, generally against the sky or a bright background.

Situation—An involved relation of affairs in a drama.

Smoke Pots—A firework like a Roman candle which produces dense clouds of smoke. Used in fire scenes..

Soft Focus—An image not sharply defined yet giving a pleasant, dreamy rendering of the subject.

Spectroscope—An instrument for analyzing light.

Spectrum—White light spread out into its component colors.

Speed—In photography speed has a number of special meanings. Lens speed is determined by the amount of light which it can utilize for image formation. Emulsion speed refers to its relative sensibility to light. Camera speed refers to the number of frames exposed per second. Shutter speed to the quickness with which it can open and close, and so on.

Spiral Reel—A developing rack which holds the film in a spiral.

Spirit Figures—See Ghosts.

Spirit Gum—An adhesive used for attaching false hair in making up.

Split Reel—A thousand foot reel containing more than one subject. Almost obsolete now.

Split Stage—In trick work where a fraction of the set is taken at one time and the remainder at another.

Spoken Title—Any phrase in a subtitle supposed to have been spoken by an actor. Spoken titles are never shown with decorative background.

Spot—Short for spotlight, a lighting unit which projects a concentrated spot of light.

Sprocket—A toothed wheel in a camera or projector which propels the perforated film like a sprocket chain.

Staff Writer—A scenario writer engaged on a salary basis.

Star—The actor who is featured in a stage or motion picture production.

Static—Discharges of frictional electricity which sometimes make branch like markings on motion picture films.

Step Printer—A machine which prints a motion picture step by step, a "frame" at a time.

Stereoscopic—A picture that gives the same illusion of looking into space as the two eyes perceive in actuality.

Still—An ordinary photograph—called still to distinguish it from a motion picture.

Stinemann—Name of inventor and manufacturer of the only practical, portable, developing equipment for motion picture films.

Stock—See Negative Stock.

Stop—Lens diaphragms are called stops.

Stop Motion—Making a motion picture one frame at a time. Used on natural objects it gives the appearance of impossibly swift, jerky motion and is often used for comedy effects.

It is also used in animated work where the figures which are to simulate motion are moved slightly between each exposure.

Studio—A place where motion pictures are made.

Sun Shade—A shade to keep the sunlight from falling on the lens of the camera.

Supers—See Extras.

Super Speed—Motion pictures taken at several times normal speed; also called slow motion because when shown at normal speed the subject seems to move at very slow speed.

System, F—A system of marking lens diaphragms in terms of the focal length.

System U—Uniform System, a system of marking diaphragm stops in numbers corresponding to their relative speed.

Tanks—Large containers in which films are developed in quantity.

Tank System—Developing in a tank according to a table calculated for time and temperature.

Tape Line—Used by motion picture cameramen to measure the distance from lens to object so that the lens may be set to the distance scale without having to focus for sharpness.

Telephoto Lens—A lens which gives a large image of a distant object.

Test—1. A short piece of film developed to ascertain whether the exposure and focus are correct.

2. A short picture made of an actor to "test" his action and appearance on the screen.

Test Chart—See Chart.

Threading—Placing film in a camera or projector ready to operate.

Thin—A negative or positive in which the silver image is thin or transparent.

Timing—Determining the printing light value necessary to make a good positive.

Tinted Film—Film that has been dipped in dye to color the high lights.

Titles—The printed captions in motion picture film.

Toned Film—Film in which the image has been changed to another color by a chemical solution.

Topical Film—News film.

Trick Work—Making films showing impossible actions or occurrences.

Triple Exposure—A film made by exposing the same film in the camera three times.

Tripod—The three legged camera support.

Ultra Speed—See Super Speed.

Ultra Violet—The invisible rays of the upper region of the spectrum. They act strongly on sensitive emulsions.

Under Exposure--Not enough light has been allowed to pass the shutter to give the proper exposure.

Uniform System—See System.

Vignette—A picture the details of which blend away to nothing at the edges.

Violet Rays—See Ultra Violet.

Vision—An effect showing the thought or dream of an actor by means of double exposure.

Weak Negative—See Thin Negative.

Wide Angle Lens—A lens of short focus which takes in a wide field of view.

Wohl Lamps—Hard Lights of the arc type.

X-Back—Negative film coated on the back with gelatine to eliminate frictional electricity which causes static markings.

Zoetrope—A motion picture toy.

Avoirdupois to Metric

Grains	Grams	Grains	Grams	Grains	Grams	Grains	Grams
1	0.065	6	0.389	10	0.648	60	3.888
2	0.13	7	0.454	20	1.296	70	4.536
3	0.194	8	0.518	30	1.944	80	5.184
4	0.259	9	0.583	40	2.592	90	5.832
5	0.324	10	0.648	50	32.40	100	6.480

Ounces	Grams	Ounces	Grams	Ounces	Grams
¼	7.09	0.1	2.83	1	28.35
½	14.17	0.2	5.67	2	56.70
¾	21.26	0.3	8.5	3	85.05
		0.4	11.34	4	113.40
		0.5	14.17	5	141 75
		0.6	17.01	6	170.10
		0.7	19.84	7	198.45
		0.8	22.68	8	226.80
		0.9	25.51	9	255.15
		1.0	28.35	10	283.50

English—Metric Conversion Tables

Inches to Millimeters

Inches	Mm.	Inches	Mm.	Inches	Mm.
1/32	0.8	5/16	7.9	¾	19.1
1/16	1.6	11/32	8.7	13/16	20.6
3/32	2.4	⅜	9.5	⅞	22.2
⅛	3.2	7/16	11.1	15/16	23.8
3/16	4.8	½	12.7	1	25.4
7/32	5.6	9/16	14.3		
¼	6.4	⅝	15.9		
9/32	7.1	11/16	17.5		

Millimeters to Inches

Mm.	Inches	Mm.	Inches	Mm.	Inches
1	0.04	10	0.39	19	0.75
2	0.08	11	0.43	20	0.79
3	0.12	12	0.47	21	0.83
4	0.16	13	0.51	22	0.87
5	0.20	14	0.55	23	0.90
6	0.24	15	0.59	24	0.94
7	0.28	16	0.63	25	0.98
8	0.31	17	0.67		
9	0.35	18	0.71		

Metric Weight to Avoirdupois

Note: All photographic formulae are compounded by avoirdupois weight unless otherwise specified.

Grams	Grains	Grams	Grains	Grams	Oz.	Grains
0.1	1.5	1	15.4	10		153.9
0.2	3.1	2	30.9	20		308.8
0.3	4.6	3	46.3	30	1	25
0.4	6.2	4	61.7	40	1	180
0.5	7.7	5	77.2	50	1	334
0.6	9.1	6	92.6	60	2	51
0.7	10.8	7	108	70	2	203
0.8	12.4	8	123.1	80	2	360
0.9	13.9	9	138.5	90	3	76

Grams	Ounces	Grains	Grams	Ounces	Grains
100	3	230	600	21	70
200	7	24	700	24	300
300	10	250	800	28	95
400	14	50	900	31	325
500	17	280	1000	35	120

Metric to English Rapid Conversion Table—Length

Decimal Fractions Represent Parts of English Inches

No. of Units	Millimeters	Centimeters	Decimeters	Meters
1	.03937	0.3937	3.937	39.37
2	.07874	0.7874	7.874	78.74
3	.11811	1.1811	11.811	118.11
4	.15748	1.5748	15.748	157.48
5	.19685	1.9685	19.685	196.85
6	.23622	2.3622	23.622	236.22
7	.27559	2.7559	27.559	275.59
8	.31496	3.1496	31.496	314.96
9	.35433	3.5433	35.433	354.33
10	.3937	3.937	39.37	393.7

Example—What is the focal length in inches of a lens marked 46 mm.? 46 millimeters equals four centimeters plus six millimeters or 1.5748 inches plus .23622 inches or 1.81102 inches.

What is the English equivalent for 12.637 meters? This is resolved into 10 meters plus 2 meters plus 6 decimeters plus 3 centimeters plus 7 millimeters. This is changed by reference to the table above to this sum in simple addition.

$$
\begin{array}{r}
393.7 \\
78.74 \\
23.622 \\
1.1811 \\
.27559 \\
\hline
497.51869
\end{array}
$$

497.51869 inches or approximately 41.45989 feet, disregarding the sixth decimal point.

Thermometric Conversion Tables

Both Fahrenheit and Centigrade systems of

measuring temperature are common in this country, while the Reaumur system is not as common. We may regard the Reaumur system as obsolete and confine our attention to the Fahrenheit and Centigrade systems only. Fahrenheit system takes 32° as freezing and 212° as boiling, while the Centigrade starts with zero as freezing and 100° as boiling. Fahrenheit is our common system, while Centigrade is the scientific system and a part of the metric system of measurement.

To Change Fahrenheit Reading to Centigrade:

Subtract 32, multiply by 5 and divide by 9.
Example—65°F — 32 × 5 ÷ 9 = 18.33°C.

To Change Centigrade Reading to Fahrenheit:

Multiply by 9, divide by 5 and add 32.
Example—20°C × 9 ÷ 5 = 36. 36 + 32 = 68°F.

Fahrenheit-Centigrade Comparison Scale in 5° Steps

F	C	F	C	F	C
0°	17.78°	70°	21.11°	145°	62.78°
5°	15°	75°	23.89°	150°	65.55°
10°	12.22°	80°	26.67°	155°	68.33°
15°	9.44°	85°	29.44°	160°	71.11°
20°	6.67°	90°	32.22°	165°	73.89°
25°	3.89°	95°	35°	170°	76.67°
30°	1.11°	100°	37.78°	175°	79.44°
32°	0°	105°	40.55°	180°	82.22°
35°	1.67°	110°	43.33°	185°	85°
40°	4.44°	115°	46.11°	190°	87.78°
45°	7.22°	120°	48.89°	195°	90.55°
50°	10°	125°	51.67°	200°	93.33°
55°	12.78°	130°	54.44°	205°	96.11°
60°	15.55°	135°	57.22°	210°	98.89°
65°	18.33°	140°	60°	212°	100°

The up-to-date and scientific cinematographer will adopt the Centigrade system of tempreature measurement in his laboratory along with the other metric measurements.

Exposure

Classification of Subjects

Various subjects require various exposures. The relative length of such exposures may be determined by the following tables. We will consider the exposure given on a bright day, for clouds in the sky, the most brilliantly lighted subject we have, as the unit.

Clouds	1
Open sea	2
Distant landscape, snow, open beach, river, etc.	4
Light foreground subject, no near objects	8
Ordinary subjects	16
Close up dark objects	32
Very close, very dark objects	64
In cast shadow, open woods, etc.	128
In heavy woods and darkest outdoor locations	256

Relative Exposures for Various "f" Values

Rel. Value	1	4	9	13.25	20.25	31.36	39.69	64	121	256	484
"f" No....	1	2	3	3.5	4.5	5.6	6.3	8	11	16	22
Rel. Ex....	1	4	8		16		32	64	128	256	512

The last set of figures show the geometric progression from unity and shows how closely the relative values of f 1.5, 2, 3, 4, 5.6, 8, 11, 16 and 22 approximate these progressive values. So we may say that with the f values 1, 1.45, 2, 3, 4, 5.6, 8, 11, 16, 22 each member of the group requires just one-half the exposure speed of the succeeding one.

Relative Exposures According to Light

With the most brilliant illumination, say a midsummer's day with brilliant sunshine, we may approximate the exposure upon standard cine negative as for the brightest subject. This will be 1/64,000 second at f 1. For bright, but not brilliant light we multiply by 1½. For plain cast shadows in diffused light we multiply by 2. For dull light and faint shadows we multiply by 3. For heavy light and no shadows we multiply by 4 or 5.

Example—What is the exposure for average subject in bright midsummer sun, slightly diffused light, aperture f 8.

Basic exposure 1/64,000 second, f 1 to f 8 = 64 ratio. 1/64,000 multiplied by 64 equals 1/1000. Basic exposure for f 8 = 1/1000. Subject ratio 1:16, then $1/1000 \times 16 = 1/62.5$. $1/62.5 \times 1.5$ (light factor) = 1/42 second approximately correct exposure.

Formulae Used in Abnormal Exposure Speeds

In processes involving abnormal exposure speed, such as time condensation, animation and such work, the speed of cranking, if continuous or the inter-exposure interval if the exposure is intermittent, must be carefully calculated.

The speed or interval should be of such duration that the image upon the negative will move about 0.01 inch or 0.25 millimeter. In this case we have standard film with a frame 24 millimeters wide. With a motion of ¼ millimeter per frame, we will have to use 24 x 4 or 96 frames of film to carry the object entirely across the frame. This means that six feet of film will

be used, or that the object will move entirely across the screen in six seconds. As this motion is seldom in a straight line, it is a fair average, but if the subject is to be rendered with even better detail, the single frame advance can be held to 0.1 millimeter which will give us a cross screen movement in fifteen seconds.

Examples:

a. Slow Moving Objects Such as Clouds

The subject is allowed to cross the field of vision while being observed in the finder. If the cross screen speed of six seconds is desired and we find that the travel across the finder requires one minute, we know that we must expose 96 frames of film in one minute or 96 frames in 60 seconds. This is 1½ frames per second. This may be approximated by using the trick crank and turning slightly slower than normal speed.

b. Very Slow Motion, as Plant Growth

Usually used with small plants showing first stages. We know the approximate time which will be required. Let us say that this is six weeks. In order to observe the growth, we will want to give this growth at least two minutes screen time. 16 x 60 x 2 is 1920, the number of frames to be used. We have six weeks equal to forty-two days, 1028 hours, 61,680 minutes, or 3,700,800 seconds. At normal speed this would require 59,212,800 frames of film. We see that we have 1920 exposures to make in 1028 hours. In round numbers this will be one exposure every half hour. This will give us 2048 frames or 128 frames more than we had counted upon. This will cause our film to run eight seconds over-

time. So we use a thirty minute interval in our exposure.

c. To Photograph a Cartoon in Process of Animation

A convenient size for the separate sheets of drawings is 18 x 24 inches. In this case we have a ratio between the sheet size and frame size which is equal to the ratio existing between inches and millimeters.

We proceed as in example (a) to determine the rapidity of cross screen movement and we will suppose that the six second rate is determined upon. We know then that the image must move about ¼ millimeter per frame, and as we have an inch to millimeter ratio, the cartoon will advance ¼ inch per exposure. The same calculations may be made in regard to dolls, models or other animation.

In arm movements, this speed may be greatly accelerated, the movement being increased to as much as one inch per exposure. In turning the head, the start and finish is all that is necessary. Detailed motion is seldom necessary except in case small objects are being shown.

In cases involving wheels, gears and so forth, turning, great care must be used. As such a wheel will be divided into sections by spokes, teeth or other projections, these parts must serve as units for the motion. The forward motion must never exceed 1/3 such unit space, for if the advance of motion is less than one and more than one-half, the wheel will rotate in reverse direction. If the advance is one and one-third the effect will be identical with that obtained by advancing the wheel one-third. This is supposing that all divisions of the wheel are identical.

d. Objects Moving too Rapidly for Shutter

This brings up a new point. With slow motions, we can easily make the proper computation, but with rapid motions we must use another process.

The motion picture film may have considerable blur due to motion, because in real life we do not clearly perceive an object in rapid motion, but there is a well defined limit to such permissible blur and this should not exceed, in lineal measurement, more than about 50% of the distance travelled normally. Thus if an object travels normally, 1/4 millimeter upon the negative, the blur should not exceed 1/8 millimeter with a total permissible motion of 3/8 millimeter.

Photography of Moving Objects

Moving objects are photographed from three principal angles. In the determination of these angles, the direction of progression of the object forms one leg of the angle, while the optical axis of the camera lens forms the other leg. The intersection will form an angle which will be roughly ninety degrees (object moving directly across field), forty-five degrees (object moving obliquely into camera) and zero degrees (object moving directly toward camera).

We have seen that in order to "stop" motion, the image must not move more than a certain distance upon the negative. In considering any given object then, we will see that inasmuch as the long focus lens gives us a larger image it will give us a more rapid motion of the image upon the negative, even though the speed of the object remains the same. So we have to make allowance for the focal length of the lens. We can

also see that the greater the distance, the less its relative motion upon the negative emulsion, so that the distance must also be considered. But, the size of the plate makes no difference. If we use the formula:

$$E = \frac{D}{100\ F \times S}$$

and in which E = Exposure; D = Distance of object in feet; F = Focal length of lens; S = Speed of object in feet per second, we shall arrive at a fair approximation of the correct speed for preventing blur. This is for objects moving at right angles. For objects moving obliquely toward the camera, use a 50% increase in exposure and for objects moving almost directly toward the operator, an exposure three times as long as indicated may be used. In motion pictures the allowable exposure in any case may be increased by fifty per cent.

Relative Exposure Speeds for Shutter Apertures Expressed in Degrees

Degrees	180	140	120	100	90	60	45	30
Fraction of Second	1/32	1/41	1/48	1/57	1/64	1/96	1/128	1/192

Degrees	25	20	15	10	5
Fr. Sec.	1/230	1/288	1/384	1/576	1/1152

One degree gives an exposure of 1/5760 of one second at normal crank speed. Then

$$E = \frac{5760}{D}$$

in which E = Exposure in fractions of second, and D = Angular opening of shutter in degrees.

Angles of View

It is sometimes quite necessary to know the

included angle of view of the lens in use. As this is a problem for practical use, the horizontal angle will be considered rather than the full conical angle. To secure the angle, divide one by the focal length. The quotient will then indicate the angle as shown below.

Quotient	Angle	Quotient	Angle
0.353	20	1.53	75
0.443	25	1.678	80
0.536	30	1.833	85
0.631	35	2.0	90
0.728	40	2.182	95
0.828	45	2.38	100
0.933	50		
1.041	55	2.856	110
1.155	60		
1.274	65	3.464	120
1.4	70		

Example—What is the angle of view of the 2 inch lens?

Solution: ½ = 0.5. This lies between 0.443 and 0.536 which indicates an included angle of between 25 and 30 degrees, which may be estimated at 27.5 degrees which is only a half degree error. This approximation is quite satisfactory for ordinary work.

Quick Reference Hyperfocal Scales

The following scales of hyperfocal distances indicate that point at which the lens is set to secure full sharpness of everything which lies not closer than one-half the hyperfocal distance and from that to infinity. By setting the lens at the hyperfocal distance, the motion camera is used as a

fixed focus camera. These tables are based on a circle of confusion not larger than 1/500th inch in diameter. The first column indicates the focal length (F.L.) of the lens, the second the size of the aperture as indicated by its "f" value (f), and the third is the hyperfocal distance itself.

F.L.	*f.*	H.F.D.	F.L.	*f.*	H.F.D.
35 mm.	2	40 feet	35 mm.	4.5	20 feet
35 mm.	2.7	30 feet	35 mm.	6.3	13 feet
35 mm.	3.5	24 feet	35 mm.	8	10 feet
42 mm.	2	52 feet	42 mm.	4.5	26 feet
42 mm.	2.7	40 feet	42 mm.	6.3	20 feet
42 mm.	3.5	33 feet	42 mm.	8	13 feet
2 inch	2	87 feet	2 inch	4.5	40 feet
2 inch	2.7	53 feet	2 inch	6.3	26 feet
2 inch	3.5	47 feet	2 inch	8	20 feet
3 inch	2	240 feet	3 inch	4.5	92 feet
3 inch	2.7	142 feet	3 inch	6.3	53 feet
3 inch	3.5	108 feet	3 inch	8	40 feet

The distance as given here is greater than that usually given due to the extremely small circle of confusion. If these tables are adhered to, the resulting film wil be of such quality that it will be acceptable for exhibition in the finest theatres.

For news and general work, the following formula is sometimes used (the measurements all being metric): (Circle of confusion = 0.1 mm.)

$$\frac{\text{Focal length} \times \text{focal length} \times 10}{\text{"f" value}} = \text{Hyperfocal distance.}$$

This formula is not recommended for any valuable work, as it is only a rough guide.

Projection Size

It is often desirable to have the projected image

of some certain, predetermined size, for example, life-size. Let us suppose that you wish to project the image of a six foot man, life-size. We have certain fixed factors to which we shall assign arbitrary values for purposes of explanation. We shall suppose that the screen measures 9×12 feet, that standard film is being used with a two inch lens. Now if the man is to be six feet tall upon the nine-foot high screen, he will fill two-thirds of the screen. It follows that he must fill two-thirds of the frame, and 2/3 of ¾ equals 2/4 or ½. Therefore we wish to secure an image ½ inch high upon the film. We shall have to make use of certain formulae in which the following factors are used. R = ratio of reduction or size of object divided by size of image. E = ratio of enlargement or size of image divided by size of object. D = distance of object from lens. F = focal length of lens. Now we have the formula $D = \frac{F}{E} + F = (R + 1) \times F$. Now according to our factors D = the unknown distance, $R = 72/0.5 = 144$, $E = 0.5/72 = 0.007$ and $F = 2$. Then $D = \frac{2}{0.007} + 2 = 287.7$ inches or just under 24 feet. Again $(R + 1) \times F = (144 + 1) \times 2 = 145 \times 2 = 290$ inches or 24 feet, 2 inches. The discrepancy of two inches is a result of not carrying the decimals to infinity. If we place the man at twenty-four feet, we will gain the desired result and it follows that any object at a distance of 24 feet from the lens of the camera will be projected practically life size, always provided a two inch camera lens is used and that the screen measures 9×12 feet.

To check this result we use the formula $R = \frac{D}{F} - 1$ or scale of reduction equals 290 inches divided by two, and one taken from the result. This gives us 144, the exact scale of reduction under the circumstances described.

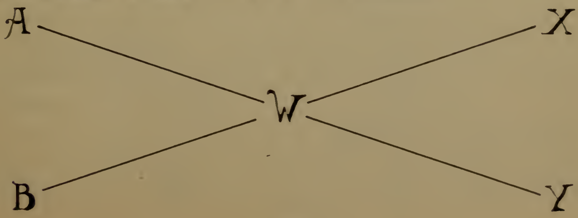
Thus we may determine the distance at which to place an object to secure a given size of image, or we may determine the size of the image of any object of known dimensions at any given distance from the camera.

Percentage Solutions

Many formulae call for a solution of a certain per cent strength. The following table gives the amount of chemical which has to be dissolved in one fluid ounce of water to make the required strength.

To Make	Use Grains	To Make	Use Grains
1%	4.557	10%	45.57
2%	9.114	15%	68.355
3%	13.671	20%	91.14
4%	18.228	25%	113.925
5%	22.785	50%	227.85

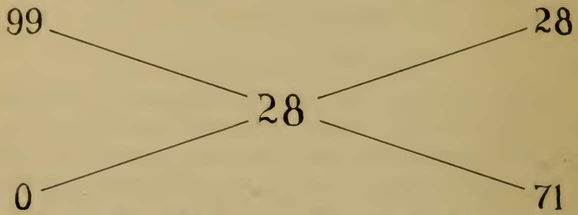
Often, however, we have solutions of a certain percentage from which we must make other percentage solutions. In this case the following dilution formulae furnished by the **Mallinckrodt Chemical Works** is very convenient.



Place at A the percentage strength of the stock solution; at B the percentage strength of solution used to dilute with (in case of water this will be "O"); at W the percentage strength desired.

Subtract W from A and place remainder at Y; substract B from W and place remainder at X. Now by mixing parts of A and Y and parts of B you will have the desired percentage solution.

Example: To dilute 99% acetic acid to 28%:



Take of the 99% acid 28 parts, and of water 71 parts, mix and the mixture will be 28% acetic acid.

Table of Solubilities

It is frequently of advantage to know just how much of any certain chemical may be dissolved in either cool or boiling water. When mixing stock solutions it is possible to so saturate the solution that no more will be dissolved. In the following table, the more common photographic chemicals are listed.

Dec = decomposed; m = miscible in all proportions; s = soluble; sl. = slightly soluble; insol = insoluble. Table indicates parts soluble in 100 parts of water.

Chemical	60°F	212°F
Acid, acetic	m	m
Acid, citric	140	200

Acid, hydrochloric	m	m
Acid, Nitric	m	m
Acid, Sulphuric	m	dec
Alum, ammonia	..	..
Alum, potash	13	358
Alum, chrome	9.5	50
Amidol	42	..
Borax	6	200
Copper sulphate	40	100
Eikonogen	4.2	12
Ether, sulphuric	8	dec
Glycerine	m	m
Glycin	..	..
Gold chloride	100	133
Hydroquinone	5.8	10 at 90°F
Ferric chloride	160	s
Ferrous chloride	140	s
Metol	s	s
Paramidophenol	1.2	s
Potassium bromide	50	102
Potassium carbonate	149	305
Potasium bichromate	12	94
Potassium cyanide	1000	dec
Potassium ferricyanide	40	775
Potassium ferrocyanide	28	50
Potassium iodide	120	200
Potassium metabisulphite ..	33	s
Potassium permanganate ...	6.5	10
Pyrogallic acid	40	s
Silver chloride	insol	insol
Silver nitrate	100	200
Silver bromide	insol	insol
Sodium bicarbonate	10	dec
Sodium carbonate	93	445
Sodium chloride	35	39.6
Sodium hydrate	60	127

Sodium hyposulphite .... 100 s
Sodium sulphite 25 100

Developers

Number Sixteen

Water ....1 gallon
Metol ....18 grains
Sodium sulphite ....5-1/3 ounces
Hydroquinone ....352 grains
Sodium carbonate ....2½ ounces
Potassium bromide ....50 grains
Citric acid ....40 grains
Potassium metabisulphite ....90 grains

M-Q

Water ....1 gallon
Sodium sulphite ....3 ounces
Hydroquinone ....340 grains
Sodium carbonate ....2 ounces
Metol ....21 grains
Citric acid ....26 grains
Potassium Metabisulphite ....85 grains

Contrast or Title Developer

Water ....1 gallon
Sodium sulphite ....2½ ounces
Hydroquinone ....385 grains
Sodium carbonate ....2½ ounces
Potassium bromide ....50 grains

Universal M. P. Negative Developer

Water ....1 gallon
Metol ....34 grains
Sodium sulphite ....3 ounces
Hydroquinone ....130 grains
Sodium carbonate ....1 ounce

Potassium bromide	20 grains
Citric acid	40 grains

Universal M. P. Positive Developer

Water	1 gallon
Metol	30 grains
Sodium sulphite	2¼ ounces
Hydroquinone	60 grains
Sodium carbonate	1¾ ounces
Potassium bromide	22 grains
Sodium hydroxide	100 grains

Developer for Reversal

Water	1 gallon
Sodium sulphite	11 ounces
Hydroquinone	1 ounce
Sodium carbonate	7 ounces
Potassium bromide	1 ounce

High contrast developer giving reversed prints which are far superior to the usual "flat" reversed positive.

Reversal Bath

Water	1 gallon
Potassium bichromate	1½ ounces
Nitric acid	3 ounces

Reversal Developer (Second)

Use developer given above or any metol-hydroquinone formulae the choice being governed by the degree of contrast wanted.

Fixing Bath

Water	1 gallon
Hypo	2 pounds

Dissolve and add the following hardener

Water	4 ounces
Sodium sulphite	175 grains
Powdered alum	350 grains
28% acetic acid	2½ ounces

Alternative Fixing Bath

Water	1 gallon
Hypo	2 pounds
Hardener:	
Water	10 ounces
Sodium sulphite	1 ounce
28% acetic acid	6 ounces
Powdered alum	1 ounce

Pathe Reversal Process

The following is one of the most satisfactory methods of securing positives by reversal yet produced.

The films are divided roughly into four classes, according to the time required for the image to appear in the first developing bath. This factor determines the total length of development.

Class	First Appearance	Total Development
A	Within first 20 seconds	About 6 minutes
B	20 to 40 seconds	About 12 minutes
C	40 to 60 seconds	About 15 minutes
D	Up to 1½ minutes	Maximum 25 min.

In the case of severely underexposed films the absolute maximum period of development is 28 minutes.

First Developer

Para-phenylene-Diamine compound (Pathe) 1 oz. 22 gr.

Sodium hydroxide .... 150 gr.
Water .... 35 ounces

When film is developed according to class, it is rinsed and placed in the reversal bath.

Reversing Bath

Potassium permanganate .... 30 grains
Sodium bisulphate .... 380 grains
Water .... 35 ounces
(170 minims sulphuric acid may be substituted for the sodium bisulphate.)

Treat in this bath for 7 to 10 minutes until dense black deposit is removed. Wash thoroughly and then continue process in full daylight. It is placed in the

Clearing Bath

Sodium bisulphate .... 75 grains
Sodium sulphate .... 75 grains
Water .... 35 ounces

Allow to remain until whites are transparent, then add to above bath
Sodium Hydrosulphite .... 150 grains

This forms the second developer. Allow to remain until image is fully darkened, wash thoroughly and dry. The above mentioned chemicals may be obtained from Pathe Freres, Vincennes, France.

To Reduce Films Which Are Too Dense

A Bath

Water .... 1 gallon
Hypo .... 8 ounces

B Bath

Water .... 16 ounces
Potassium ferricyanide .... 1 ounce

Mix immediately before use.

Place in bath until density is sufficiently reduced, always rinsing film before examining to prevent streaks. Wash thoroughly and dry. This reducer increases contrast.

To Intensify Thin and Weak Films

A Bath

Water ....1 gallon
Mercury bichloride ....2 ounces
Potassium bromide ....2 ounces

Allow to remain in this bath until thoroughly whitened, rinse carefully and place in

B Bath (mix fresh)

Water ....1 gallon
Sulphite of sodium ....16 ounces

Allow to remain until thoroughly cleared.

Note—Film must be thoroughly washed and free of hypo before intensification.

Toning Films

The sepia tone is about the only one permissible in the small laboratory. The process is:

The thoroughly washed film is placed in the

Bleach

Potassium bromide ....400 grains
Potassium ferricyanide ....3 ounces
Water ....1 gallon

Film is allowed to remain in the bleach until all blacks have turned to buff. It is rinsed for not more than one minute and then placed in the

Sulphide Bath

Sodium sulphide (Not sulphite)......20 ounces
Water ....1 gallon

When thoroughly toned, which should be within thirty seconds, the film is rinsed and dried.

Dead Black Paints and Varnishes for Cameras and Equipment.

Inside of Cameras

Alcohol .... 8 ounces
Lamp black .... 2 ounces
Shellac .... 1 ounce

Dissolve shellac in alcohol, add lamp black and stir.

For Metal Parts

Nitric acid .... 4 ounces
Copper metal .... ¼ ounce

Dissolve copper in acid and **slowly** add 1¼ ounces of water. The part is heated, immersed in above solution and polished.

For Wood

Borax .... 30 grains
Glycerine .... 30 minims
Shellac .... 60 grains
Water .... 8 ounces

Boil until dissolved and add black dye.

Nigrosine .... 60 grains

For Wood

Cupric chloride .... 75 grains
Potassium bichromate .... 75 grains
Water .... 2¼ ounces

Apply to wood, when dry apply following:

Aniline hydrochlorate .... 150 grains
Water .... 2¼ ounces

For Brass

A Bath

Copper nitrate ....200 grains
Water ....1 ounce

B Bath

Silver nitrate ....200 grains
Water ....1 ounce

Mix A and B. Immerse brass, remove and heat.

For Aluminum

Clean with emery, wash and place in:

Ferrous sulphate ....1 ounce
White arsenic ....1 ounce
Hydrochloric acid ....12 ounces

When dissolved add

Water ....12 ounces

Dry and Lacquer.

Substandard Sizes

In the substandard field we have several sizes, some of which are known as substandard and others as off-sizes. Some of the better known are:

9½ mm. gauge ....Pathex, Cine-Nizo
16 mm. gauge....Eastman Cine-Kodak, Bell & Howell Filmo, Oxford, Victor, Salex, Cine-Nizo, Cine-Geyer, and others
17½ mm. gauge....Ernemann, Movette, Pathe-Rural, etc.
24 mm. gauge........Pathescope, Victor Safety

The last mentioned size has become practically obsolete as it lacks advantages of both 35 mm. (standard) and of substandard films.

As the celluloid ribbon is nothing more than a vehicle for the emulsion, its size has little to do with the picture size. For purposes of full comparison, let us compare the widths of the ribbon (the gauge), the size of the actual frame, the area of the frame, and finally the relation of this frame area to the area of the standard film.

Film Gauge	Frame Size	Frame Area	Relative Area
35 mm.	18 x 24 mm.	437 sq. mm.	1.000
9½ mm.	7½ x 8½ mm.	63.75 sq. mm.	0.150
16 mm.	7½ x 10½ mm.	78.25 sq. mm.	0.179
17½ mm. (a)	8.2 x 11 mm.	90.20 sq. mm.	0.206
17½ mm. (b)	9½ x 13½ mm.	128.25 sq. mm.	0.293
17½ mm. (c)	11½ x 15 mm.	172.50 sq. mm.	0.395
35 mm.	18 x 24 mm.	437 sq. mm.	1.000

Of the 17½ mm. gauges, the letters a, b, and c refer to:

(a)—Half normal film, or split standard film with unilateral perforations;

(b)—Pathe Rural film;

(c)—Ernemann 17.5.

Roughly speaking, the 9½ mm. gauge frame is 15% of standard, while the 16 mm. gauge is not quite 18%, or a difference in the sizes of 3%.

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*Black face figures indicate illustration.

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